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ABSTRACT

This report attempts to supply information on energy conservation mechanisms that can be employed in schools to the public schools of Minnesota. The report begins by presenting guidelines for developing an energy conservation plan. The two models include the concept of Total Educational Energy Management as developed by the Colorado Department of Education, and a program for energy management developed by the Council of Educational Facility Planners which was instituted in Minneapolis in 1974. The report then examines methods available to districts for identifying excessive and unnecessary energy use in school buildings. The three methods examined include: (1) a computer simulation model (PSECS) developed by Educational Facilities laboratories; (2) the Mini-Audit System developed by the Minnesota Energy Agency; and (3) an extensive Maxi-Audit that can be performed by engineering firms. The third section of this report examines operational, maintenance and retrofitting measures that can be used by school districts to conserve energy. (Author/MR)

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Energy Conservation

An Examination of Energy Conservation Mechanisms As They Relate to School Districts in Region XI

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SE 025 448

FOREWORD

During the energy crisis of the 1976-77 school year, the Commission on Educational Planning and Research requested that the ECSU staff undertake a study of energy conservation mechanisms and alternatives which were currently being employed or which could be effectively employed by school systems in Region XI. It was their intention that the information derived from such a study would make assistance available to districts and individual school plants in their attempts to both conserve energy and to provide responsible leadership in the nation-wide effort to eliminate energy wastage.

The following report was compiled by Marilyn Kerns, ECSU Research Assistant, from energy conservation research findings and literature in the field. It reflects the initial stage of what is intended to be an on-going project aimed at aiding school systems in Region XI to develop and institute energy management programs. We hope that it provides assistance, which is its intent, and that in so doing it will encourage Region XI public schools to assume leadership roles in the effort to conserve our nation's energy resources.

An Examination of Energy Conservation Mechanisms As They Relate to School Districts in Region XI

Introduction

In attempting to meet the problems caused by the high cost and increasing scarcity of energy supplies, public school systems need to have access to information regarding energy conservation mechanisms which they can employ. This report attempts to supply such information for Minnesota schools in Region XI.

The report begins by first presenting some guidelines for developing an energy conservation plan. The two models considered include the concept of Total Educational Energy Management, an approach developed by the Colorado Department of Education, and a program for energy management developed by the Council of Educational Facility Planners which was instituted by the Minneapolis Public School System in 1974.

The report then examines methods available to districts for identifying excessive and unnecessary energy use in school buildings. The three methods examined include: a computer simulation model (PSECS) developed by Educational Facilities Laboratories, the Mini-Audit System developed by the Minnesota Energy Agency, and an extensive energy use audit (Maxi-Audit) that can be performed by qualified engineering firms.

The third section of the report surveys techniques which can be employed by school districts to effectively and efficiently conserve energy. Both operational and maintenance (O&M), and retrofitting measures are examined.

Developing an Energy Conservation Plan

In order for schools to effectively confront problems arising from the current energy situation, extensive district-wide cooperation is needed. A comprehensive energy conservation program demands an organizational plan which realistically coordinates the aspects of planning, development, implementation, and evaluation. Two such plans are presented here.

The TEEM Approach

The Total Educational Energy Management (TEEM) approach was developed by the Colorado State Department of Education.[1] This approach includes:[2]

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[1] Calvin E. Anderson, District Level Plan for Conservation: The TEEM Approach, Vol. I of Colorado Department of Education Energy Conservation Materials Package, Interstate Energy Conservation Leadership Project, Denver, Colorado: 1977.

[2] Ibid., p. 2.

1. A board of education policy declaring definitive statements for a strong energy management program.
2. Formation of a small but strong, persuasive district-wide energy conservation committee.
3. Establishment of a task force in every school plant in the district.
4. Assignment of specific responsibilities to specific individuals.
5. Careful planning in the development of energy usage guidelines and monitoring procedures.
6. Recording energy use patterns - "an energy audit" - for each building in the district.
7. Persistent follow-up and evaluation efforts to see that established energy usage guidelines are followed.

The first step in implementing this plan is the formation of an energy conservation team. Membership in the team could include a district-wide energy coordinator responsible for the administration of the program, the superintendent, building principals, maintenance and custodial staff supervisor, transportation staff supervisor, business manager, and board of education, teacher and student representatives.

The second step in this approach entails planning for the development of district energy usage. During this phase assignments of responsibilities and tasks are made, strategies for involving the entire community are developed, energy audit methods are determined, goals and an appropriate time frame are established, and, if appropriate, consultations with outside experts are arranged.

Once the planning and organization phase is underway, a school building-level task force is developed. The principal, acting as plant energy coordinator, and task force members who are representative of school personnel, students and community members, are responsible for implementing district-level guidelines and programs.

The follow-up and evaluation phase of this approach requires that the district committee collect energy information on each school facility concerning the type and amount of fuel used each month and the amount of electricity used by KWH. This information is collected in monthly reports, resulting in a continual monitoring of the district's energy plan.

Materials which further describe this approach are available from the Colorado State Department of Education. Volume I, District Level Plan for Conservation, and Volume II, School Plant Energy Task Force Plan for Conservation of the Energy Conservation Materials Package may be obtained by writing to:

Calvin E. Anderson
Energy Project Director
Colorado Department of Education
201 East Colfax Avenue
Denver, Colorado 80203

Programming Energy Management

A more theoretical energy conservation organizational plan was developed by the Council of Educational Facility Planners.[3] The guidelines for developing this model emphasize the importance of securing commitments by administrators, the board of education, and the state department of education to an energy conservation plan. Once these commitments are assured, the model suggests that the board of education establish an energy management committee which has policy-making responsibilities for the prospective program. The suggested composition of the team includes: members of the board of education, superintendent, district energy manager, district facility planners, public relations personnel, appropriate central office staff, and energy experts.

In this model the actual programs and activities of the energy plan are developed and carried out by an energy conservation team which is headed by a district energy manager who is directly accountable to the energy management committee. It is noted that creating the energy manager's position is necessary not only for the practicalities of administration, but also for providing the program with the status and authority necessary to insure its success. The composition of the conservation team should include: building principals, teachers, students, maintenance supervisor, school business administrator, representatives from community councils, representatives from utility companies, and consultants. Once the membership of the team is determined, members should have extensive in service training and education concerning the planning, development, implementation, and evaluation of an energy program. This training should be aimed at helping the team fulfill its responsibilities for collecting data essential for needs assessments, decision-making, energy monitoring and evaluation, and for channeling this information into program goals and activities.

Once the methods of energy auditing and reporting are determined, building level task forces are initiated to implement activities on an individual facility level. The members of this task force are to receive training to carry out their responsibilities from conservation team members.

In evaluating the energy program, the model suggests that three questions be answered: Are the task force activities being implemented and to what extent? Are the task force activities actually meeting the stated program objectives and to what extent?; and Did the stated program objectives accomplish the program goals?

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[3]The plan described was presented as a model at a series of "Energy Workshops" presented by the Council of Educational Facility Planners International in conjunction with the Federal Energy Administration in 1976-77. It is described in more detail in materials found in Workshop on Managing Energy Use, Council of Educational Facility Planners International, section on "Programming Energy Management."

It is emphasized that throughout all phases of the operation of this model the public be made aware of program objectives, activities and effectiveness. In this manner public cooperation with schools is encouraged and the school serves as a "model" for energy conservation.

The following diagram further illustrates the organizational aspect of this energy management plan.[4] (see Diagram A)

In order to further illustrate the application of this plan, excerpts from a summary of a report on its implementation by the Minneapolis Public School System are presented in Appendix I.

Materials which further describe this plan may be obtained from:

Council of Educational Facility Planners International
29 West Woodruff Avenue
Columbus, Ohio 43210

Methods of Identifying Energy Conservation Opportunities

PSECS Method

The Educational Facilities Laboratories, in conjunction with the Federal Energy Administration, has developed a computer modeling technique that can be used as a first step for any conservation program. The Public Schools Energy Conservation Service (PSECS) provides reasonably accurate information which compares reported energy consumption in a given school with desirable levels of energy consumption for that school.

The service is able to provide approximate computer simulation of energy use at individual plants by making use of the similarities of plant characteristics and patterns of use found in most American schools. The basic similarities of schools built during given periods of educational and architectural philosophy and technology, permit the grouping of plants into generic types, based on their physical characteristics. The basic characteristics used in the generic classification system are described in Appendix II.

The generic classification system makes it possible to simulate the actual operation of most schools by constructing a small number of such factors as climate, use pattern, various combinations of mechanical equipment, and special physical features (see Appendix II).

The PSECS system operates as follows:

When a school district shows an interest in the use of PSECS for an indication of relative energy efficiency, PSECS sends the district a form on which to indicate significant aspects of the design, systems, programs, and energy consumption of the school. A sample form is provided in Appendix II.

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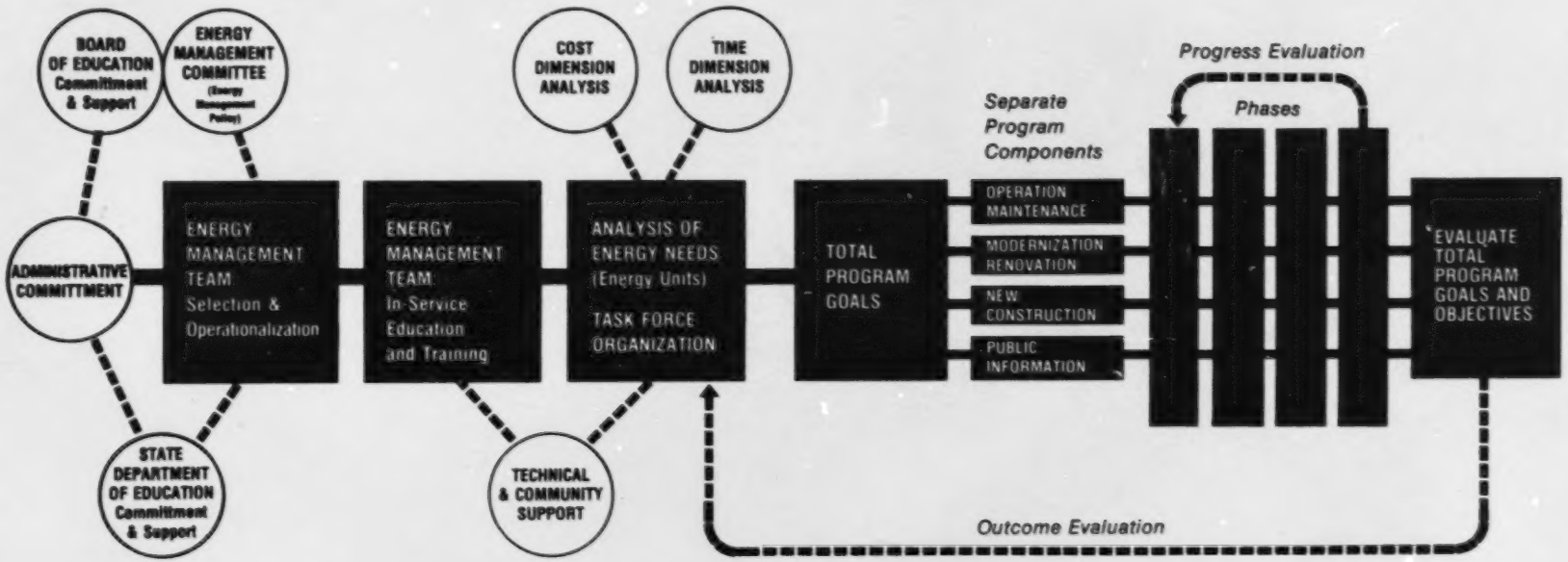
[4] Ibid.

DIAGRAM A

MODEL SCHOOL DISTRICT ENERGY MANAGEMENT PLAN



When this form is filled out and returned, PSECS categorizes each building according to type and this information is entered into the computer for an indication of abnormal energy consumption. These computer outputs are then returned to the school district accompanied by instructions for their interpretation.

If a district decided that further study should be made, it can request additional assistance from PSECS in the form of a Self-Audit plan and/or the Capital Modification Program. In the Self-Audit plan, PSECS provides a number of conservation proposals that might be applicable to a building having the characteristics of the school in question. Operating personnel and school administrators can review and apply the suggested conservation measure that they deem appropriate. If the district determines that even further assistance is needed, they can ask PSECS for a Capital Modification Program for the buildings identified as having excessive energy use. In order to operate this plan, the PSECS model needs further information regarding physical plant characteristics and its operation. With this additional data, PSECS prepares a list of investments in capital improvements that would save energy. The cost of these modifications are shown and a projection of energy cost savings are made. Sample computer printouts for all PSECS reports are presented in Appendix II along with estimated costs for these services.

The following diagram further illustrates the PSECS process.[5] (see Diagram B)

Districts can obtain further information regarding this service from:

John Boice
Educational Facilities Laboratories, Inc.
3000 Sand Hill Road
Building 1, Suite 120
Menlo Park, California 94025

Mini-Audit Method

The concept of the Mini-Audit was developed largely by the Minnesota Energy Agency with the cooperation of several interested Minnesota utility companies and engineering firms. The following description of such audits was written by the Agency:[6]

> Mini-Audits are one to two hour audits that are conducted by individuals or teams of specialists who walk through a facility observing and analyzing building structure, systems, operational practices, and other factors that relate to energy consumption. Two (2) major areas of possible energy savings receive special attention: Measures that could be implemented quickly and at little or no cost, usually in the operations and maintenance area (O&M) and retrofitting possibilities that would require some, though not extensive, capital investment.

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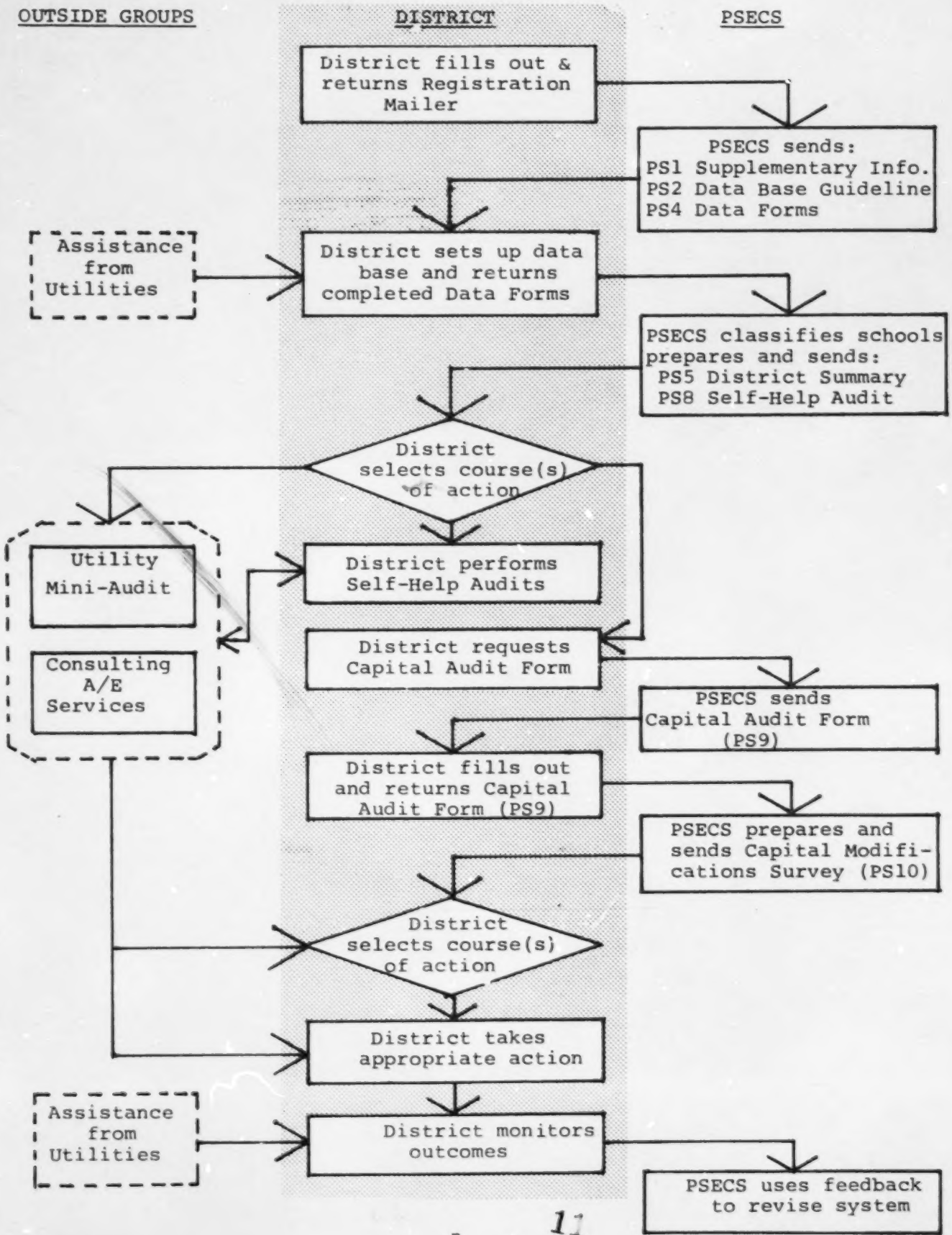
[6]Minnesota Energy Agency, The Chicago Project, St. Paul, Minnesota: February, 1976, p. 13.

DIAGRAM B

PSECS PROCESS


OUTSIDE GROUPS
DISTRICT
PSECS
District fills out & returns Registration Mailer
PSECS sends:
PS1 Supplementary Info.
PS2 Data Base Guideline
PS4 Data Forms
Assistance from Utilities
District sets up data base and returns completed Data Forms
PSECS classifies schools prepares and sends:
PS5 District Summary
PS8 Self-Help Audit
District selects course(s) of action
Utility Mini-Audit
Consulting A/E Services
District performs Self-Help Audits
District requests Capital Audit Form
PSECS sends Capital Audit Form (PS9)
District fills out and returns Capital Audit Form (PS9)
PSECS prepares and sends Capital Modifications Survey (PS10)
District selects course(s) of action
District takes appropriate action
Assistance from Utilities
District monitors outcomes
PSECS uses feedback to revise system

It is suggested that Mini-Audit teams be comprised of an experienced HVAC systems engineer, a representative of the gas and/or electric utility or fuel company that supplies fuel to the school, the chief operating engineer for the building, and one or more administrators from the school or district. It is emphasized that one or more of these team members should have had prior experience in conducting a Mini-Audit.

The Mini-Audit team conducts the audit by investigating the current operating and maintenance practices for the building, surveying the heating and/or climate control system, noting the building type, age, and state of repair, and generally attempting to determine how the building is constructed and how it is operated. After compiling this data, the team prepares a report of its findings, which includes a summary of the conditions found in the school along with recommendations for changes in operating practices, building components, and instrumentation that should result in energy savings. A sample copy of a Mini-Audit report is presented in Appendix III.

After preparation of this report, it is presented to school personnel for use as a tool for implementing immediate conservation measures and for identifying the need for a more extensive audit procedure.

Although the cost of this method is greater than it is for the PSECS method, ranging from $100-200, it has the particular advantage of providing recommendations that are specific to a given building and its operation, rather than being derived from a system relying on generic types. Mini-Audits are not currently available throughout the country, but they are obtainable for schools in Minnesota. Districts desiring further information regarding the Mini-Audit method should write to:

Minnesota Energy Agency
Conservation Division
740 American Center Building
150 East Kellogg Boulevard
St. Paul, Minnesota 55101

Maxi-Audit Method

The Maxi-Audit method provides the greatest amount of information on conservation measures which are applicable to a given educational facility. The audit is performed by a consulting engineer or other qualified contractor who prepares a thorough analysis of current energy use in a school facility and identifies measures that would reduce energy consumption.

If districts desire this extensive auditing procedure, they should carefully consider the qualifications of a variety of available engineering firms, and should attempt to choose a firm with prior experience in energy management and energy

conservation programs. (A sample Maxi-Audit contract is presented in Appendix IV). The procedures utilized in this audit will probably vary from contractor to contractor, but the outcome of these procedures should be to provide the district with an accurate comparison of actual energy usage and projected usage if conservation measures were to be employed.

The report that results from a Maxi-Audit should include the following information: a complete inventory of energy-using equipment, the calculated energy budget for the building, current deviation from the calculated energy budget, fuel and cost savings that would result from recommended changes in operations and maintenance practices, and fuel and cost savings.

Although this auditing method is rather expensive, the cost ranging from $8,000-10,000, it has the distinct advantage of providing specific costs for any recommended retrofit work based on local consideration rather than national averages. Thus, it provides district personnel with the opportunity to begin with immediate planning for implementation of extensive conservation measures, based on specific, practical data.

Districts desiring further information regarding the Maxi-Audit method should contact the Minnesota Energy Agency, whose address was previously noted.

Conclusions and Recommendations Regarding Auditing Methods

Working in conjunction with the Federal Energy Administration, the Minnesota Energy Agency studied and compared the three auditing methods described here. Their conclusions are written up in The Chicago Project[7] and have been summarized by the Minnesota Agency in a document entitled Chicago Study Summary.[8] Excerpts from that summary are listed below:[9]

1. All school districts should plot energy use data and make this information available to operating personnel in each school facility.
2. A PSECS type of energy audit should be used on all school buildings in the United States.
3. When PSECS audits are used, school districts should pay particular attention to providing highly accurate information on the forms.
4. School administrators should urge the department of education in each state to assemble enough Mini-Audit teams that all interested schools will have reasonable access to this service.
5. Whenever possible, Mini-Audits should be performed during times when school is in session and the heating system is operating.

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[7] Ibid.

[8] Minnesota Energy Agency, Three Energy Conservation Audits for Schools: Chicago Study Summary, April, 1976.

[9] Ibid., pp. 9-10.

6. Whenever possible, Mini-Audits should be performed during times when school is in session and the heating system is operating.
7. When a Mini-Audit is used, one or more of the "team" members should be asked to make an in-person presentation of findings in addition to providing a written report.
8. In those cases where a PSECS audit and/or a Mini-Audit have been performed and their recommendations implemented, if energy consumption for a facility still appears to be excessive, a Maxi-Audit should be performed.
9. Model contracts for Maxi-Audits should be developed and made available to all interested school districts through Federal Energy Administration offices or through appropriate agencies in each state.
10. All Maxi-Audits should be awarded in accordance with terms and conditions suggested by a model Maxi-Audit contract after such time as the model contract becomes available.

Specific Energy Conservation Measures

This section of the report will present specific measures which can be adopted by school districts to conserve energy in individual school plants.

The first conservation measures are suggested as guidelines for energy usage for schools and were prepared by the New York State Education Department Task Force onFuel Allocation and Conservation. The second list of possible conservation measures was prepared by the Minnesota Energy Agency as a result of their findings from actual Mini-Audits.

Whatever measures of energy conservation are decided upon, it must be stressed that their effectiveness is dependent upon their being a part of an over-all district energy management program. It is only within the confines of a well organized, rational attack on energy waste that specific conservation measures prove to have any lastingly significant effect.

Energy Usage Guidelines[10]

These guidelines emphasize that the administrative role in an energy conservation program is of primary importance. Measures which it is suggested that administrators consider include:[11]

1. Allowing only the most essential weekend and nighttime activities, eliminating as many meetings and conferences as possible, curtailing community use of facilities on weekends, scheduling athletic events after school hours in the afternoon, scheduling extra-curricular activities to take place in a minimum number of heating and ventilating or air-conditioned zones.

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[10] "Energy Usage Guidelines: Educational Institutions," developed by the New York Education Department Task Force on Fuel Allocation and Conservation, Albany: University of State of New York, 1974.

[11] Ibid., p. 4.

2. Reviewing scheduled hours of custodial operation, especially in cleaning functions, to take advantage of daylight, thereby reducing the use of electric lights and reducing the total hours of running time of mechanical equipment.
3. Having cafeteria perpare "cold-type" lunches at intervals so that steamers and steam-jacketed kettles are used only intermittently.
4. Planning essential after-hour activities to take place in a minimum number of heating and ventilating or air-conditioned zones.
5. Arranging for the chief custodian to periodically "walk-thru" buildings of nearby institutions for observations and discussion with other custodians of mutual problems, individual solutions, and comparison of yearly fuel consumption costs.
6. Entering into a control service contract or properly train "in-house" personnel to repair, recalibrate and adjust inoperative or ineffective controls.
7. Converting to modern efficient equipment when aged equipment is shown to be inefficient.

These guidelines also list several specific operational and maintenance measures which can be employed within each school facility. It is noted that each checklist must be analyzed individually and only those measures appropriate to a specific facility should be adopted.

Supervisory/Custodial Responsibilities[12]

Winter Season Heating and Ventilating Checklist

——Set thermostats in occupied sedentary space to 68 degrees F. maximum room air temperature. Morning heat-up operating temperatures should not be in excess of 65 degrees in the space to allow for sensible heat gain from occupants of the building. Avoid use of extra boiler to bring temperatures up to acceptable level in less than two hours.

——Areas of physical activity such as shops, gymnasiums, corridors and toilet rooms should be set 3 to 5 degrees lower than sedentary spaces.

——Storage and similar non-student spaces may be maintained at 50-55 degrees F. Caution: do not permit freezing of systems.

——Set night control cycle as early in the day as possible. Night setback should be automatic. Except during extremely cold weather, study feasibility of complete heating plant shutdown during unoccupied hours.

——Set night control temperatures at least 8-10 degrees F. less than daytime temperature. By experimentation, adjust night temperature when desired daytime temperature cannot be obtained within about an hour after start of morning heat-up.

——Modify schedule of heating during weekends by maintaining unoccupied areas at absolute minimum temperature levels (50-55 degrees F.). Do not permit freezing of systems.

——Steam pressure or hot water temperature should be decreased at the boiler.

——Shut down boilers at all times when outside temperature is 56 degrees F. and rising (when domestic hot water is obtained from other means than boilers). In elementary schools without showers, domestic hot water heaters may be shut down. (Essential needs for kitchen must be maintained as required.)

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[12] Ibid., pp. 4-9.

——Discontinue fresh air intake. Recirculate inside air until, by experimentation, interior conditions make some fresh air intake desirable by a 15 to 20 minute 'purge cycle' with maximum of 4 cfm fresh air per occupant. Provide a manual position switch to allow 4 cfm per person during "purge" cycles, or use automatic temperature controls to accommodate purging.

——Where "economy cycle" exists, reset mixed air temperature to take greater advantage of this cycle.

——Make certain fresh air intake dampers of the ventilating system are fully closed overnight and when bringing a building up to temperature.

——Shut off power exhausts — except toilets — on experimental basis. Use power exhausts only as necessary.

——Inspect burners-boilers for deteriorating refractories, loose doors, faulty seals and malfunctioning combustion controls and make corrections.

——Inspect steam traps, strainers, flowpumps, valves, etc., and replace if necessary.

——Make certain that all back draft dampers in exhaust fan ductwork close tightly when fans are not operating.

——Check all ductwork and piping for leakage; install and/or repair insulation on all ducts and pipe lines requiring insulation.

——Clean combustion chambers of boilers on regular schedule as required by the fuel being used. If available, consider professional cleaning companies.

——Clean scale deposits from waterside surfaces of boilers and from hot water heating coils as necessary. Chemically treat boiler water to reduce scale.

——Clean burner nozzles daily. Keep fuel oil at recommended temperature at burner tip to insure proper viscosity for complete combustion and soot-free heat transfer surfaces. Consider use of additives in heavy fuel oil to obtain better ignition, thereby reducing possibility of flame failure. Keeping tubes cleaner will result in better heat transfer. Treatment additives in oil tanks can reduce carbon, chemical action and sludge.

——Provide for adequate combustion air in the boiler room. Consider introducing exhaust air from classrooms into boiler room to be used as pre-heated combustion air.

——Clean all filters of unit ventilators, air handling systems, etc., on a regular schedule, replace as necessary.

——Clean all registers and fins of finned radiation.

——Properly adjust and clean all combustion equipment and operating controls. Calibrate temperature control equipment to conserve fuels. Balance steam, hot water and air systems for maximum utilization of power and minimum consumption of fuel (if one or two rooms are hard to heat, do not bring to temperature by overheating adjacent areas.)

——Arrange for periodic boiler combustion efficiency tests by providing for stack draft gauge, carbon dioxide analyzer, smoke analyzer and stack temperature gauge or obtain portable instruments from which equivalent readings may be obtained for properly adjusting fuel/air ratios. Install flame safeguard controls. Corrective action is needed whenever stack temperatures exceed 450 degrees F. to 500 degrees F., or whenever carbon dioxide content is less than 8% to 12%. (Instruments are more accurate than "eyeballing" a flame.)

——Make certain that all operating personnel have been properly and thoroughly instructed in equipment operation by the manufacturer of the equipment, and the consulting engineer designing such equipment.

——Establish a regular inspection schedule for checking fans, pumps, compressors, and other rotating equipment each spring and fall, and provide for subsequent maintenance.

——Provide humidistat control of swimming pool area exhausts.

——Consider providing separate heaters for domestic hot water.

——Consider installing tanks for bulk fuel storage.

Summer Season Air Conditioning and Ventilation Checklist

——In spring, check and repair cooling towers and maintain their fill and latticework; replenish refrigerant; check fans, pumps, compressors and other rotating equipment for poor seals, belt slippage and other defects (improper fan RPM/CFM may lead to frosting on coils due to reduced air flow); calibrate controls; change filters; check switch gear and distribution equipment.

——Keep tubes in water condensers clean to maximize heat transfer; provide preventive maintenance at regular intervals on all parts of air-conditioning system.

——Set cooling thermostat setting at 78 degrees F.

——During the spring and fall seasons adjust boiler water temperature to outside air temperature on heating systems and lower room thermostat temperatures to 66 degrees F.

——Shut off air-handling units and lights in gyms when physical education classes are outside in warm weather.

——Operate air-conditioning units to a minimum extent.

a. Use outside air for cooling (if the outside air is cool enough it will seldom be too humid to adversely affect the interior). Reduce O.A. intake to minimum on hot, humid days.

b. Generally, do not operate air-conditioning units through the night. Use economizer cycle during the night and early morning hours. Allow the inside air temperature to rise during the afternoon.

c. Do not operate air conditioning without first checking the weather forecast, as there are many days when one can get by without cooling, or at least delay startup.

——Make certain that thru-the-wall, window and packaged air-conditioning units have an energy-efficiency-ratio (EER) of at least 7-10 (determined by dividing the BTU cooling capacity by the wattage of the unit). Obtain data from manufacturer's catalog or equipment plate.

——Reset dampers on air-conditioning units so that cooling does not take place when the intake air falls below a specified temperature.

——Modify the air-conditioning system so that those spaces which are not in use are not cooled, or install dampers in registers of diffusers in these spaces. Beware that reduced airflow does not cause frosting on coils.

——Examine equipment to see if several air-conditioning systems can be combined so as to eliminate need to run and maintain several systems.

——Verify that insulation is provided on all steam or hot water lines passing through air-conditioned spaces, and on *all* chilled water lines; suction refrigerant lines, and ducts containing cold air.

——In non air-conditioned buildings, operate the fan system periodically at night at 100% outside air to cool the building down, taking advantage of the lower evening and night temperatures.

——Raise air intakes to heating and cooling systems as far above hot roof surfaces as possible.

——Install ducts to reduce heat pickup during cooling periods if steam tunnels are used as return air plenums.

——Reclaim heat wasted from A/C systems for hot water and heat, thus eliminating need to operate additional equipment. Or, consider providing separate boilers for summer supply of domestic hot water. (If boilers must be maintained for summer hot water, at least shut off those mains not required for water heating.)

Plumbing Checklist

——Reduce hot water temperature to 100 degrees F. except for dishwashing. Shut down hot water systems as soon as possible, relying upon stored heat for immediate after school use. Consider disposable cafeteria service items in place of having to use hot water for dishwashing.

——Reduce swimming pool water to 75-80 degrees F.

——Discontinue hot water service to lavatories and sinks (other than in kitchens).

——Limit length of use of showers to 3 minutes; install shower heads using smallest possible volume; add automatic shut-off devices.

——Repair leaking faucets.

——Install and/or repair covering on all pipe lines requiring insulation for conservation of heat loss.

Electric Checklist

——Reduce lighting to minimum foot-candle levels by removing lamps from fixtures and/or using lamps of minimum total wattages. Disconnecting ballasts of fluorescent fixtures will save additional energy versus only removing the lamps (do not remove only one lamp from a two lamp ballast circuit). Consider flexible task directed lighting (special lenses, polarizers and beam distribution devices to utilize energy more efficiently) rather than evenly illuminating unoccupied work planes throughout a space, especially in office areas. Minimum Education Department requirements for public school lighting are:

10 F.C. maintained — in auditoriums, corridors, locker rooms, toilets
20 F.C. maintained — in cafeterias, gymnasiums
30 F.C. maintained — in classrooms, studyhalls, libraries, offices, shops
40 F.C. maintained — in rooms where fine detail work is to be done

——Eliminate all display and decorative lighting.

——Reduce "on" time of all night security lighting or reduce quantity.

——Reduce time of testing emergency generators.

——Review elevator use privileges.

——Clean fixtures and lenses at least yearly.

——Keep condensers on A/C units, refrigerators, freezers and drinking fountains clean and free of foreign matter.

——Consider disconnecting electric water coolers on drinking fountains, or raising cooled water temperature from 46 degrees to 55 degrees.

——Make certain 230 V motors are not running on 208 V systems and vice-versa.

——Improve power factor as much as possible by providing proper capacitance to motors.

——Consider replacing incandescent lamp fixtures with fluorescent fixtures. (Fluorescent lamps produce three to four times as much light per watt of electricity as incandescent.) Change fluorescent lamps after 80% of their life has been used.

——Utilize time clocks or "electric eyes" where advantages of automatic operation can be realized. Consider dividing corridor lighting into sections and placing each section on timers to come on at the exact time school is opened, and to shut off a half hour after school is out.

——Add more local electric switches if necessary for more flexible and efficient control of individual lighted areas.

——Tie exhausts of individual windowless toilet rooms into light switches.

——To minimize electrical demand load charges, reduce electrical power peak demands in electric heating systems by priority selectors, demand limiters, and load shedding. Reschedule operation of all large motors, such as large electric driven water pumps, to operate at night. Stagger startup of kitchen appliances so as not to coincide with peak electrical demand (i.e., baking cycles).

General Checklist

——Do not hold exterior doors open during passage of occupants entering and leaving the building at start and finish of the day. Limit the number of entrances used during arrival and departure hours. Keep door closers in good repair; remove hold-open devices.

——Check refrigerator and freezer doors for defective gaskets.

——Weather strip doors and windows: where sash are loose fitting, consider use of caulking tape on all sash except required emergency escape windows.

——Inspect and restore exterior caulking of building enclosures.

——Install additional insulation in ceilings, soffits of overhangs, walls, crawl spaces; consider storm windows, insulating glass, vestibule enclosures, exterior door closers.

——When repainting, use light, reflective finishes within recommended ranges.

——Use trash compactors to reduce the number of trips needed by hauling trucks.

——In winter, stop localized drafts in hallways at night by closing smoke doors.

——In winter, install covers on wall and window air-conditioning units; preferably cover entire window on inside with plastic to provide the tighter seal.

——Where window areas of public schools exceed minimum sizes required by the Education Department, consider minimizing high heat loss glass areas through modifying the windows by installation of materials of greater insulating value than glass. Consider double glazing; heat resisting glass.

——The application of a pressure sensitive metallized polyester solar control film to existing glass areas will reduce heat gain of a building interior in the summer and will reduce rate at which interior heat escapes to the outside in winter. (Experiment with this film on a per room basis.)

——Awnings installed over windows of air-conditioned buildings can reduce summer heat gain by as much as 50%, especially on south and west exposures. Plant trees around buildings to shade sun.

FACULTY/STUDENT/CUSTODIAL RESPONSIBILITIES

——In winter, dress warmly to account for reduced (68 degree F.) temperature. Keep desks away from outside walls as much as possible.

——Except for emergencies, do not open windows during operation of heating system. If windows are open in warm weather, do not operate air handling or air-conditioning units.

——Keep classroom doors to corridors closed to prevent drafts in heating season.

——Make certain that furnishings, drapes, books, papers, etc. do not obstruct flow of air into and from heating units.

——Use exhaust fans in science and homemaking laboratories, shops, kitchen, etc. only when necessary. Such fans should be operated by manual switches.

——Turn off electric lights in occupied areas where windows give adequate natural light for the tasks being performed, however, when electric lights must all be turned on due to insufficient natural light (and the room is not benefitting from the "solar heat gain" of the sun) close all shades, drapes or blinds. Attempt to minimize window "glare" through means other than closing all shades, drapes or blinds.

——When summer air-conditioning is being operated, close blinds and/or drapes when solar gain through windows is high.

——Close all drapes and/or venetian blinds when leaving the classroom at the end of the day so that they remain closed at night and over weekends.

——At all times turn off electric lights when leaving an empty room.

——Turn off supplemental lighting, such as bench lights in shops and labs, when not in use.

——Shut down all electric equipment when not in use. Do not leave electrically powered office equipment, such as copiers, "on" all day. Develop schedules for use. Turn off electric typewriters when not in use. Make discriminating use of audio-visual equipment.

——Preheat kitchen ovens only for necessary periods.

——Wait for full load of clothes before drying them in laundry room dryers.

——Use cold water cleaning wherever possible. Select cleaning supplies with cold water effectiveness in mind.

——Be constantly aware of the energy shortage and observant of any way, no matter how trivial, to conserve the energy supply. Make suggestions.

The administration may wish to consider placing approximately 5"x7" signs over classroom light switches reminding teachers, pupils, and custodians of their responsibility.

Energy Conservation Measures Suggested by the Minnesota Energy Agency

The following conservation measures were developed by the Minnesota Energy Agency as a result of their conducting several Mini-Audits[13] in the Mid-West. The measures are suggested for specific building types which are outlined below.[14]

Types 1 and 1A - Prewar Low Energy Schools

Type 1A has mechanical cooling.

Dates of completion: 1920-1940
Plan type: double-loaded corridor
Construction: heavy frame and heavy walls

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[13] Minnesota Energy Agency, Minnesota Mini Energy Audit Program.

[14] Ibid., p. IV.

Mechanical systems: hot water or steam boiler, radiation type system

Lighting: originally incandescent, now largely high level fluorescent (2.0 or more watts/sq. ft.)

Classroom glass: 40 to 60 per cent of exposed wall

Types 2 and 2A - Postwar Low Energy Schools

Type 2A has mechanical cooling.

Dates of completion: 1945 to present

Plan types: double- or single-loaded corridors

Construction: light frame and light walls

Mechanical systems: hot water or steam boilers, unit ventilators or similar type systems

Lighting: incandescent or low fluorescent, high level fluorescent if modernized

Classroom glass: 70 to 90 per cent of exposed wall

Types 3 and 3A - Artificial Environment Schools

Type 3A has mechanical cooling.

Dates of completion: ca. 1965 to present

Plan types: compact

Construction: as Type 2

Mechanical systems: sophisticated air handling, as single- or double-duct, variable air volume, multizone, etc.

Lighting: high level fluorescent

Classroom glass: less than 40 per cent, 5 to 15 per cent typical

Following are the lists of energy conservation measures which the Agency developed for specific types of school facilities. It is noted that each district should decide which of these suggestions are most applicable for their particular situation.[15]

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[15] Ibid., pp. 1-15.

Type 1 and 1A Schools

SPACE HEATING CONSERVATION MEASURES

1) Consider having a competent combustion engineer make a flue gas analysis at least once each year to properly adjust the fuel input and to check combustion.

2) Consider making the energy consumption and cost data available to the school principal and chief operating engineer so that they can evaluate and compare against previous months, normal budget, and perhaps against other schools.

3) Consider changing the spring, fall and winter day-night timeclock settings to operate heating equipment fewer hours on the day cycle.

4) Consider connecting all of the manual day-night control switches to timeclocks so that night setback temperatures can be achieved even if inadvertently left on "day".

5) Consider derating the boiler(s) (decrease gas or oil input) so that the boiler(s) will operate over longer periods of time, decreasing off cycle losses.

6) Consider installing modulating oil burners to eliminate continuous cycling.

7) Consider converting to a low pressure system to improve the heating system annual operating efficiency. The installation of small steam electric boilers near the termination of some steam lines may reduce the need for piping modifications.

8) Consider reinsulating the outer surface of the boilers to reduce heat loss.

9) Consider installing turbulators in boiler tubes to increase the heat transfer from the hot gases to the water side.

10) Consider insulating the exposed steam and condensate lines in classrooms.

11) Consider increasing the steam differential to increase the length of time the boiler stays on the line to reduce the energy loss during pre- and post-purge cycles.

12) Consider measuring with the gas meter the fuel consumption of the boiler on manual versus automatic firing. During moderate temperature periods, the manual low fire setting should result in the boiler operating longer periods of time at a higher efficiency.

13) Consider installing automated damper controls to provide positive draft shutoff when the boiler is not operating.

14) Consider readjustment of damper control to maintain proper draft under both high and low fire.

15) Consider informing teachers and building operators of possible savings by closing shades at night.

16) Consider automating boilers to start automatically when space temperature drops below a preset night temperature.

17) Consider installing a night thermostat to automatically control steam pressure during night hours to maintain the night setback temperature.

18) Consider the installation of an outside temperature reset controller to control steam pressure based on ambient temperatures.

19) Consider installing automatic steam control valves on some radiators to reduce the need for opening windows in rooms that overheat.

20) Consider adding some type of a key switch to hallway radiation valves so that the students cannot change the setting of the steam valves.

21) Consider adjustable vent air valves on radiators to aid in balancing system.

22) Consider operating the boilers off of a timeclock during the spring and fall seasons and not permitting them to come on line during the night cycle.

23) Consider leaving one of the two boilers off during most of the winter heating season and perhaps during the entire season if the other boiler is capable of carrying the entire load under design conditions. A single boiler carrying the building space heating load will operate at a higher annual efficiency than two boilers dividing the load.

24) Consider setting all thermostats at 68°F for winter space heating.

25) Consider reducing the space heating hot water temperature to the lowest temperature that will satisfy heating needs.

26) Consider turning off the boiler natural gas standing pilot during the summer months when the boiler is off.

27) Consider lowering steam pressure to minimum pressure that will heat the building.

28) Consider revising the boiler control system so that the exhaust damper will be closed instead of open when the boiler operating control is satisfied.

DOMESTIC HOT WATER CONSERVATION MEASURES

1) Consider reducing the domestic hot water temperature to 110°F or less.

2) Consider shutting off the hot water heater(s) during the summer when the school is unoccupied.

3) Consider installing a small domestic hot water heater to maintain the desired temperature in the water storage tank to eliminate the need for running one of the large space heating boilers at a very low efficiency during the summer months.

4) Consider insulating pool heat exchangers and adjacent steam piping.

5) Consider replacing the existing shower heads with units that will allow no more than 2 gpm water flow.

6) Consider shutting off circulating lines when possible to reduce radiation losses.

VENTILATION SYSTEM CONSERVATION MEASURES

1) Consider adjusting the timeclock day-night settings to operate ventilation units fewer hours during the day cycle.

2) Consider operating the ventilation system only when the school is occupied. Also, consider shutting off the air handling units on normal heating days before school is out. If the steam radiators are located properly, they should be able to maintain space temperatures above freezing.

3) Consider adjusting the manual fresh air dampers to reduce the quantity of outside air heated by the ventilation system. Also, consider modifying the ventilation system to permit more return air to be recirculated. If this is done the fresh air/return air should be controlled with motorized dampers.

4) Consider operating the gym 100% outside air ventilation unit on a reduced operating schedule that coincides with occupancy of the gym. Also, consider the possibility of changing the outside air damper setting to reduce the amount of outside air brought into the gym when the fan unit is operating. The gym fan unit should not be turned on until the first class occupies the gym and should be turned off immediately after the class leaves the gym in the afternoon.

5) Consider reinsulating some of the steam piping, especially near the air handling units.

6) Consider valving off steam headers in the boiler room to individual air handling units when off to reduce steam piping heat losses.

7) Consider not operating the ventilation units at all during the spring and fall because many of the windows in the classrooms are open during this time of the year.

8) Consider not operating the ventilation system at all except for pickup on cold mornings.

9) Consider operating the ventilation units with no outside air whenever the outside temperature is 25°F or below. There should be sufficient fresh air leakage through the dampers to provide adequate ventilation.

10) Consider installing an automation system to operate the ventilation units so that supply air temperature and return air/fresh air dampers can be adjusted to maintain the desired space temperature in the rooms.

LIGHTING SYSTEM CONSERVATION MEASURES

1) Consider acquiring energy conservation reminders such as posters and individual decals that can be located next to the light switches and on bulletin boards to alert both teachers and building staff that turning off lights is their responsibility.

2) Consider new high efficient light sources and fixtures when remodeling.

3) Consider using light colored reflective paint when redecorating.

4) Consider leaving the classroom exterior (window side) light switch off on sunny days to take advantage of outside natural lighting.

5) Consider raising the blinds and turning off the lights in those classrooms that have one full wall of windows.

6) Consider photo-cell control rather than timeclock on security lights.

7) Consider replacing the gym incandescent lighting systems with mercury vapor or other high efficiency source.

8) Consider initiating a training program to orient the gym instructors and the students in the proper operation of gym lighting so that no more than 50% to 75% of the lights are on at any one time when the gym is occupied, provided switching is available.

9) Consider the possibility of installing a desk lamp for the instructors so that they can occupy the classroom without all of the lights being on.

10) Consider leaving the hallway lighting off on those hallways facing the interior courtyards during daylight hours, assuming a light meter reading indicates the lighting level is satisfactory.

11) Consider cleaning fixture lenses more often to improve lighting efficiency.

BUILDING STRUCTURAL CONSERVATION MEASURES

1) Consider weatherstripping all of the windows to reduce the infiltration If this is done the school may be maintained at a positive pressure with the addition of very little outside air.

2) Consider weatherstripping the outside doors to reduce air infiltration.

3) Consider recaulking around all of the windows if existing caulking has cracked.

4) Consider reinsulating the ceiling with some type of spray-on insulation. It might also be possible to consider blowing a mineral wool insulation on the top of the ceiling plenum or batt type between ceiling joists.

5) Consider covering and insulating the upper half of the exterior windows to reduce heat loss.

6) Consider adding storm windows to every other window of the building. Storms on 50% of the windows would still leave enough windows for ventilation during spring and fall schedules.

7) Consider adding another set of doors on the main entrances so that this area will serve as a vestibule.

SPACE HEATING CONSERVATION MEASURES

1) Consider having a competent combustion engineer make a flue gas analysis at least once each year to properly adjust the fuel input and to check combustion.

2) Consider making the energy consumption and cost data available to the school principal and chief operating engineer so that they can evaluate and compare against previous months, normal budget, and perhaps against other schools.

3) Consider changing the spring, fall and winter day-night timeclock settings to operate heating equipment fewer hours on the day cycle.

4) Consider connecting all of the manual day-night control switches to timeclocks so that night setback temperatures can be achieved even if inadvertently left on "day".

5) Consider starting the furnace ventilation fans later in the morning and shutting off earlier in the evening. Consider operating furnace fans on continuous "day" or "occupied" setting only while rooms are normally scheduled to be occupied. In mild weather, operating time can be much shorter due to the fact "pick-up" is faster. Classrooms should be up to temperature setting when class starts.

6) Consider operating the boilers off of a timeclock during the spring and fall seasons and not permitting them to come on line during the night cycle.

7) Consider operating only one of the space heating water pumps during spring and fall and possibly during the entire year. Consider adjusting the timeclock to permit heating pumps to operate fewer hours on the day cycle.

8) Consider leaving one of the two boilers off during most of the winter heating season and perhaps during the entire season if the other boiler is capable of carrying the entire load under design conditions. A single boiler carrying the building space heating load will operate at a higher annual efficiency than two boilers dividing the load.

9) Consider installing night thermostats to operate the ventilation fans on nights and weekends instead of the on-off cycle with timeclocks. Night setting or "unoccupied" should start fan and burner with outside air "closed" to maintain minimum room temperature.

10) Consider connecting the space heating hot water pumps to the timeclock so that they will only operate when the boiler is on line.

11) Consider setting all thermostats at 68° for winter space heating.

12) Consider reducing the space heating hot water temperature to the lowest temperature that will satisfy heating needs.

13) Consider installing turbulators in the boiler tubes to improve the heat transfer within the boilers.

14) Consider installing an outdoor temperature sensor that will adjust the boiler water temperature or steam pressure based on outside ambient temperatures.

15) Consider turning off the boiler natural gas standing pilot during the summer months when the boiler is off.

16) Consider building penthouse type enclosures around rooftop units to reduce radiation and wind losses from exposed ducts.

17) Consider informing teachers and building operators of possible savings by closing drapes and shades at night.

18) Consider lowering steam pressure to minimum pressure that will heat the building.

19) Consider revising the boiler control system so that the exhaust damper will be closed instead of open when the boiler operating control is satisfied.

DOMESTIC HOT WATER CONSERVATION MEASURES

1) Consider reducing the domestic hot water temperature to 110° or less.

2) Consider operating only one of the domestic hot water heaters. If one unit carries the load, leave the other off for standby.

3) Consider shutting off the hot water heater(s) during the summer when the school is unoccupied.

4) Consider replacing the shower heads with units that will allow less than 2 gpm water flow.

VENTILATION SYSTEM CONSERVATION MEASURES

1) Consider a temperature control training program for the operating engineers that will give them a thorough understanding of how the heating and ventilating system was designed to operate. Include optimization of energy via temperature control.

2) Consider acquiring the services of a temperature control expert to check and adjust all system controls and to recommend modifications.

3) Consider adjusting the timeclock day-night settings to operate ventilation units (unit ventilators) fewer hours during the day cycle.

4) Consider turning off all electricity to classrooms during unoccupied hours during spring and fall to keep unit ventilators from running 24 hours per day if remote electric power panels are conveniently located.

5) Consider leaving the multi-purpose room (gyms and auditoriums) ventilation unit in the night position at all times except when the room is occupied.

6) Consider increasing the mixed air temperature setting on unit ventilators to 65° to 68°F. If this is not practical, consider adjusting the fresh air linkage so that the mixed air temperature cannot go below

7) Consider reducing the minimum outside setting on all unit ventilators and rooftop units to permit less fresh air under design winter conditions.

8) Consider changing all fresh air limit control settings to make them consistent.

9) Consider increasing the multi-purpose room (gyms and auditoriums) ventilation units mixed air temperature from 55°F to 65° - 68°F to reduce the heating requirement during the winter.

10) Consider readjusting fresh air limit controllers from winter to summer earlier than the middle of May.

11) Consider modernizing unit ventilator systems to economizer type control so room thermostats sense and control mixed air temperature for free-cooling but close outside air when heat is needed.

12) Consider cleaning the filters more often to increase the overall efficiency of the air handling units.

13) Consider shutting off the secondary hot water pumps located in the air handling units during the spring, fall and summer when heating is not required.

14) Consider reducing the temperature of the hot deck in each multi-zone unit.

LIGHTING SYSTEM CONSERVATION MEASURES

1) Consider acquiring energy conservation reminders such as posters and individual decals that can be located next to the light switches and on bulletin boards to alert both teachers and building staff that turning off the lights is their responsibility.

2) Consider new high efficient light sources and fixtures when remodeling.

3) Consider using light colored reflective paint when redecorating.

4) Consider leaving the classroom exterior (window side) light switch off on sunny days to take advantage of outside natural lighting.

5) Consider raising the blinds and turning off the lights in those classrooms that have one full wall of windows.

6) Consider photo-cell control rather than timeclock on security lights.

7) Consider replacing the gym incandescent lighting systems with mercury vapor or other high efficiency source.

8) Consider initiating a training program to orient the gym instructors and the students in the proper operation of gym lighting so that no more than 50% to 75% of the lights are on at any one time when the gym is occupied, provided switching is available.

BUILDING STRUCTURAL CONSERVATION MEASURES

1) Consider weatherstripping the existing operable awning type windows with a thin rubber gasket strip.

2) Consider weatherstripping the outside doors to reduce air infiltration.

3) Consider covering and insulating a portion of the window covered with blinds with rigid insulation and a metal panel.

4) Consider installing rigid insulation between metal panels located below windows.

5) Consider increasing roof insulation when reroofing.

6) Consider recaulking around all of the windows if existing caulking has cracked.

Type 3 and 3A Schools

SPACE HEATING CONSERVATION MEASURES

1) Consider having a competent combustion engineer make a flue gas analysis at least once each year to properly adjust the fuel input and to check combustion.

2) Consider making the energy consumption and cost data available to the school principal and chief operating engineer so that they can evaluate and compare against previous months, normal budget, and perhaps against other schools.

3) Consider hiring an engineering consultant to review and develop heating system standard operating procedures.

4) Consider changing the spring, fall and winter day-night timeclock settings to operate heating equipment fewer hours on the day cycle.

5) Consider connecting all of the manual day-night control switches to timeclocks so that night setback temperatures can be achieved even if inadvertently left on "day".

6) Consider operating the boilers off of a timeclock during the spring and fall seasons and not permitting them to come on line during the night cycle.

7) Consider operating only one of the space heating water pumps during spring and fall and possibly during the entire year. Consider adjusting the timeclock to permit heating pumps to operate fewer hours on the day cycle.

8) Consider connecting the space heating hot water pumps to the timeclock so that they will only operate when the boiler is on line.

9) Consider leaving one of the two boilers off during most of the winter heating season and perhaps during the entire season if the other boiler is capable of carrying the entire load under design conditions. A single boiler carrying the building space heating load will operate at a higher annual efficiency than two boilers dividing the load.

10) Consider shutting off boilers during the spring and fall when the air conditioning machine is off and temperature control is not neede

11) Consider setting all thermostats at $68^{o}F$ for winter space heating.

12) Consider reducing the space heating hot water temperature to the lowest temperature that will satisfy heating needs.

13) Consider reducing the steam pressure to the lowest pressure that will satisfy heating needs.

14) Consider installing a small gas or electric steam boiler near the pool heat exchanger to satisfy this heating requirement and also a small gas fired domestic hot water heater in the boiler room to eliminate the need for operating the large steam boilers during the summer months.

15) Consider adjusting the boiler so that during the spring, summer and fall the boiler will come on line at low fire and stay on low fire until the heating requirement is satisfied. We feel that the boiler will cycle less often and maintain a higher overall annual efficiency with this operating procedure.

16) If the hot water boilers must be operated during the spring, summer and fall, consider shutting off one or more of the hot water pumps so that hot water valves that do leak will not pass hot water into the air handling hot water coils, increasing the heating requirement.

17) Consider changing the night setback temperature from 60°F to 55°F, especially in spring and fall when mild weather exists.

18) Consider not preheating the combustion air that is brought into the boiler room.

19) Consider installing turbulators in the boiler tubes to improve the heat transfer within the boilers.

20) Consider installing an outdoor temperature sensor that will adjust the boiler water temperature or steam pressure based on outside ambient temperatures.

21) Consider turning off the boiler natural gas standing pilot during the summer months when the boiler is off.

22) Consider building penthouse type enclosures around rooftop units to reduce radiation and wind losses from exposed ducts.

23) Consider informing teachers and building operators of possible savings by closing drapes and shades at night.

24) Consider revising the boiler control system so that the exhaust damper will be closed instead of open when the boiler operating control is satisfied.

DOMESTIC HOT WATER CONSERVATION MEASURES

1) Consider reducing the domestic hot water temperature to 110°F or less. If the kitchen does not have a hot water booster unit, it may be worthwhile installing a separate booster heater and then reducing the domestic hot water storage tank temperature to 110°F or less.

2) Consider operating only one of the domestic hot water heaters. If one unit carries the load, leave the other off for standby.

3) Consider shutting off the hot water heater(s) during the summer when the school is unoccupied.

4) Consider having a competent combustion engineer make a flue gas analysis at least once each year to properly adjust the fuel input and to check combustion.

5) Consider connecting the domestic circulating line water pumps to a timeclock.

6) Consider changing the shower heads from the existing gpm rating to 2 gpm. Also consider the possibility of adding a timer on each shower so that they cannot be left on longer than a predetermined period.

7) Check for internal scale deposits on coil-type tank heaters and delime when necessary.

VENTILATION SYSTEM CONSERVATION MEASURES

1) Consider a temperature control training program for the operating engineers that will give them a thorough understanding of how the heating and ventilating system was designed to operate. Include optimization of energy via temperature control.

2) Consider acquiring the services of a temperature control expert to check and adjust all control systems and to recommend modifications.

3) Consider sending the chief engineer to visit other buildings that have obtained significant energy savings with their HVAC automation systems.

4) Consider adjusting the timeclock day-night settings to operate ventilation units fewer hours during the day cycle. Operate ventilation units the shortest period that is acceptable.

5) Consider operating systems on "warm-up cycle" (no outside air) until classes are in session.

6) Consider operating exhaust fans only when needed. Consider separate timeclocks for these cycles. Some pressurized buildings may not require all of the exhaust fans to operate for proper ventilation.

7) Consider using minimum amounts of outside air when either heating or cooling is required and make maximum use of outside air when conditions are correct for "free" cooling.

8) Consider enthalpy controls on outside air use.

9) Consider operating air systems in gym, auditorium, cafeteria and shop areas only when areas are occupied. Consider a "start-stop" station in the area so that the authorized persons may cooperate with energy conservation recommendations.

10) Consider seperate controls and schedules for office and kitchen areas.

11) Consider heat recovery or exchange between make-up and exhaust air.

12) Consider reducing the volume of air circulated by adjusting the inlet vanes on the supply air fans. This should decrease the horsepower requirements of these units.

13) Consider increasing the ventilation units summer mixed air temperatur to minimize the air conditioning and reheat requirements.

14) Consider raising cold deck temperatures to highest that will still give acceptable humidity control.

15) Consider lowering hot deck temperatures to point that will just satisfy system.

16) Consider increasing the supply air temperatures on all air handling units to the point where at least one space served by each unit is warmer than desired.

17) Consider turning off electric reheat coils during the summer. With increased supply air temperatures; reheat may not be needed.

18) Consider sealing ducts in equipment rooms to minimize short circuitin of hot and cold air.

19) Consider maintaining filters preferably by pressure drop readings. Consider installing differential gauges.

20) Consider valving off steam or hot water lines seasonally when not needed. Do this preferably on the boiler room header.

21) Consider higher room temperature of 78°F in summer.

22) Consider periodically logging temperature and pressure readings of operating systems. By comparing these readings, subtle changes can be noted and corrections made to bring back to optimum conditions

23) Consider adjusting or replacing all supply air temperature gauges so that accurate ventilation temperatures can be read and maintained.

24) Consider combining class activities into one section of the building in the summer to eliminate the need for running all of the air handling units.

AIR CONDITIONING SYSTEM CONSERVATION MEASURES

1) Consider operating only those water pumps needed to maintain flow volume where multiple pumps are installed in parallel. This would apply to chilled water pumps and condenser water pumps.

2) Consider setting the demand limiter on the chiller at lowest setting that will maintain the building temperature.

3) Consider installing a second timeclock for the chiller equipment so that it can be started later and shut off earlier on those days when minimum air conditioning is required, making use of the building "fly wheel" effect.

4) Consider shutting off chilling equipment when the building has no real need for cooling (nights and weekends). Valve leakage can waste energy.

5) Consider supplying chilled water at highest temperature possible as lower than necessary temperatures require larger energy inputs.

6) Consider raising room temperatures seasonally by steps to match increase in outside temperatures.

7) Consider raising setting of electric drinking water coolers to reduce energy consumption.

LIGHTING SYSTEM CONSERVATION MEASURES

1) Consider acquiring energy conservation measures such as posters and individual decals that can be located next to the light switches and on bulletin boards to alert both teachers and building staff that turning off the lights is their responsibility.

2) Consider new high efficient light sources and fixtures when remodeling.

3) Consider disconnecting ballasts from fixtures where tubes have been removed. Ballasts consume a small amount of energy and will eventually burn out.

4) Consider using light colored reflective paint when redecorating.

5) Consider leaving the classroom exterior (window side) light switch off on sunny days to take advantage of outside natural lighting.

6) Consider raising the blinds and turning off the lights in those classrooms that have one full wall of windows.

7) Consider photo-cell control rather than timeclock on security lights.

8) Consider replacing the gym incandescent and/or fluorescent lighting systems with mercury vapor or other high efficiency source.

9) Consider initiating a training program to orient the gym instructors and the students in the proper operation of gym lighting so that no more than 50% to 75% of the lights are on at any one time when the gym is occupied, provided switching is available.

10) Consider installing timers on gym and field house lighting systems that will automatically shut off lights after each class.

11) Consider the installation of photo-cell and timeclock to operate some of the swimming pool lights during occupied hours.

12) Consider turning off all of the cafeteria-lunchroom lights when unoccupied and switching on by sections when cleaning.

13) Consider installation of switching capability in classrooms so certain rows of lights can be used as needed.

BUILDING STRUCTURE CONSERVATION MEASURES

1) Consider insulating penthouse room metal walls to reduce heat loss and heat gain.

APPENDIX I

In 1974 the Minneapolis Public Schools formally reacted to the energy crisis. In an attempt to obtain a better understanding of the total energy usage of the district an Energy Management Committee was formed. Members were the Associate Superintendent of Schools for Business Affairs, the Director of School Facilities and Plant Planning, two representatives from the Building and Grounds Department and the appropriate trade foremen.

This group became the decision making body on energy management matters. But day to day work on energy management demanded full-time staffing and required the creation of an Energy Management Team. Two CETA employees were placed in the Business Affairs Office, and set to work to develop a plan of action.

This team suggests alternatives to present energy use patterns, implementation of programs, monitoring and evaluation of current programs and creates materials for an awareness campaign. The Team also is responsible for publishing reports on the various programs.

The Energy Management Team then, is the school district facilitator and the Energy Management Committee is the policy body and decision maker.

Programs developed by the Energy Management Team are monitored by a computerized energy reporting system. This system provides a standard of comparison. Without this management tool it would be impossible to measure accurately progress in energy management procedures.

A program of Energy Awareness was instituted by the Energy Management Team as one of its first objectives. This program of awareness includes both instruction and information components. Examples of awareness activities include:

1) Energy Grams - A pad of pre-addressed messages available to all staff, students, and support personnel used to direct inquiries, comments, criticism and suggestions to the Energy Management Team.

Workshop on Managing Energy Use, Council of Educational Facility Planners International, "Case Studies" section.

2) Energy Updates - Memos to personnel with current energy information affecting the district, state, and nation. Light switch stickers, wall posters, bulletin board displays, all were used to carry the energy message to every building in the district.

The Awareness Program of Instruction and Information was the first step. Operations and Maintenance Guidelines followed.

The Mini-Audit Program developed by the Minnesota Energy Agency brought together skilled personnel of the school district, utility companies, and the Energy Agency in a combined program to inspect building physical facilities and operational procedures. The Audit also involved Building Maintenance Staff and Administrators.

The Mini-Audit consists of a one to two hour walk through a building usually beginning with the boiler room, heart of the heating system. Current operations are analyzed for maximum efficiency and suggestions for improved operational procedures are made. Physical facilities are inspected and both favorable and unfavorable situations are noted. Hall and classroom lighting levels are checked. Thermostat settings in every area are noted and suggestions are made for possible changes. Special activity areas such as lunchrooms, gyms, shops, auditoriums, and swimming pools, are given special consideration. Pool areas are to be kept at 78° while the classroom areas are set at 68° and halls and gyms 65°. This lower temperature is kept in all activity areas.

The state sponsored Mini-Audit Program provided our Team members with the experience required to develop the skills within themselves which makes it possible for them to conduct the Mini-Audits without outside help.

It is important to remember that school maintenance personnel and administrators are still involved. It is their involvement and support that makes this program successful. The cooperation of these building personnel in carrying out the recommendations of the Mini-Audit have made possible the energy savings to the district.

The savings may be identified by use of the Minneapolis Public Schools Energy Consumption Report. This report is updated monthly, using utility bills and meter readings as input. The information is coded and sent to the data processing center where cost and consumption amounts are calculated.

Each building is individually recorded on two reports. The first of these is a monthly breakdown by type of fuel, showing consumption and cost. The computer further breaks down the data to cost per square foot and BTU per square foot used. The second page shows totals for all energy consumed by month and year to date totals. As an example, Jordan Jr. High School built in 1922 has 143,157 sq. ft. on two floors with full basement and a wing with shops and swimming pool.

Jordan's Principal and Head Engineer can easily identify areas of improvement in energy efficiency by reviewing this report. The report is a most valuable tool to the Energy Management Team for identifying problem areas, analyzing payback ratios of energy rehabilitation projects...an example of which would be the replacement of windows at Lowry or Ericson School.

Insulation of roofs is being accomplished at the same time that roof repairs are being done. Weather stripping and caulking of windows has been undertaken by building engineers each fall from the Mini-Audit recommendations, steam pipes are being insulated.

New projects are constantly being developed and evaluated by the Energy Management Team. These include an insulating shade system being developed and tested by the 3M Company, and installed in one of our older elementary schools. The transparent shade is specially treated to allow solar heat to enter the room and also forms a dead air space by sealing itself around the window casing.

Brock Turbulators were installed at Phillips Junior High, a 1920's building. They increase the efficiency of the boiler by providing additional baffles in the fire tubes to raise their working temperatures.

Heat recovery devices were installed at the Auto Repair Shop at the Lehman Educational Service Center and the Nutrition Center in order to recover large amounts of heat normally lost when carried in the air exhaust system. Electric Power Factor Correction Equipment has been installed at the Lehman Center and Franklin Junior High School. This equipment increases the power factor, resulting in a reduced billing demand. This equipment is currently being installed in three other school locations.

To determine if the projects are achieving their desired results a strict system of monitoring is required, the Computerized Energy Reporting System gives us the basic data. This data then must be evaluated by the Energy Management Team. They analyze the results and submit payback ratios and other cost effective data to the Energy Management Committee.

These reports are then used as the basis for expanding the projects city-wide or discontinuing projects as not effective.

The savings to the district are calculated by cost savings and BTU savings. In a time of rapidly rising energy costs, per unit savings are the most acceptable tool of measurement. Results such as this reduction (7.84%) have encouraged the adoption of an Energy Management Policy by the Board of Education. The establishment of a district policy will ensure the continuation of effort toward the more effective use of energy management.

The future will see programs that allow the dollar savings made by energy management at the building level returned to the building in the form of additional educational programs. Program enrichment in the form of additional auditorium programs, additional resource people, more field trips, and other additional learning materials can be the result of good energy use.

. Test Energy Management Programs that have shown success will be expanded to other locations. The Energy Management Team and Committee will continue to search for new energy saving methods, systems, and technology. An example of this is the Computerized Electric Load Monitoring and Control System developed by a local Minneapolis firm.

The soon to be built MAVTI has proven a catalyst for energy management research. One idea presently under consideration would use the waste heat carried by the large sewerline that passes near the building to provide 70% of the heating and cooling needs of this new building.

But all programs must work toward our District Commitment. To provide the best learning environment for all students possible at the lowest energy cost per pupil. To accomplish this goal the Minneapolis schools have:

1) Established an Energy Management Policy.
2) Formed an Energy Management Committee to establish policy and make management decisions.
3) Created an Energy Management Team to facilitate day to day operations in energy management.

APPENDIX II

PSECS GENERIC TYPE DESCRIPTIONS

Types 10 and 12 - Pre-World War II Plants

Type 12 has mechanical cooling.

Dates of completion:	1920 to 1940
Plan type:	double-loaded corridor
Construction:	heavy frame and walls
Mechanical systems:	hot water or steam boiler radiation type systems (some unit vents)
Lighting:	original incandescents now largely replaced with fluorescents
Classroom glass:	40 to 60 per cent of exposed wall

Type 19 - Mix of Types 10 or 12 and 20 or 22

Types 20 and 22 - Post-War ("finger plan") Plants

Type 22 has mechanical cooling.

Dates of completion:	1945 to present
Plan types:	single- or double-loaded corridor
Construction:	light frame (single-story) heavy frame (urban and multi-story)
Mechanical systems:	hot water boiler unit ventilator or similar type systems
Lighting:	incandescent (ring) or early fluorescent now largely upgraded to fluorescent
Classroom glass:	up to 90 per cent of exposed wall

Type 29 - Mix of Types 20 or 22 and 30 or 32

Types 30 and 32 - Artificial Environment Plants

Type 32 has mechanical cooling.

Dates of completion:	about 1965 to present
Plan type:	compact
Construction:	as Type 20
Mechanical systems:	sophisticated air-handling types, such as single- or double-duct, multizone, variable air volume, etc.
Lighting:	high level fluorescent
Classroom glass:	less than 15 per cent typical

Type 38 - Mix of Types 10 or 12 and 30 or 32

Type 39 - Mix of Types 10 or 12, 20 or 22 and 30 or 32

NOTE: PSECS computer models permit interchange of characteristics between types in some areas, such as a Type 10 building with a ducted mechanical system or a Type 30 with high classroom glass percentage.

PSECS GUIDELINE CONDITIONS

I. Mechanical System

A. Mechanical system and controls operating as designed except as indicated in the following sections.

1. All routine maintenance performed and corrective actions taken.

2. All equipment and controls in good order and calibrated.

B. Temperature setback to 55°F. (winter) and fans shut-off no later than one hour after end of daily class schedule; summer setback as required by system; startup no earlier than 6 a.m., fans started no earlier than arrival of teachers (unless required by system); night use confined to one control zone if possible and other zones setback at end of day use.

C. Domestic hot water temperature 115°F. or less.

II. Lighting System

A. All routine maintenance performed and indicated corrective actions taken.

B. Lighting energy usage reduced to an equivalent of:

1. Classrooms*

E1/E2 plants:	1.5 watts/ft.^{2}
E3 plants:	2.5 watts/ft.^{2}

2. Gymnasiums: 4.0 watts/ft.^{2}

3. Auditoriums:** 0.75 watts/ft.^{2}

4. Corridors: 1.0 watts/ft.^{2}

* Equivalent to 2.0 watts per square foot installed (found by Actual Wattage procedure) but turned off when there is adequate natural light and when the room is empty (at least two (2) hours per day during time building is in use). Total lamp usage is thus about six (6) hours per day plus any evening non-custodial use.

** Equivalent to 3.0 watts per square foot installed (found by Actual Wattage procedure) but used only about two (2) hours per day.

III. Environmental Conditions

A. Inside temperature

1. Classrooms, auditoriums

Winter:	68°F.
Summer, cooled:	
No Reheat	78°F.
Reheat	75°F.

2. Gymnasiums: 65°F. (winter)

3. Unoccupied setback: 55°F. (winter)

B. Outside (clean) air requirements

1. Classrooms: 7.5 cfm/student, or 0.2 cfm/ft.^{2}

2. Gymnasiums: 0.70 cfm/ft.^{2}

3. Auditoriums: 0.75 cfm/ft.^{2}

4. Unoccupied: 0.0 cfm/ft.^{2}

A NAME OF SCHOOL DISTRICT: ANYTOWN UNIFIED | NAME OF SCHOOL: LINCOLN

B INDIVIDUAL IN CHARGE OF THIS FORM
NAME: J. DOE SIGNATURE: J Doe DATE:
ADDRESS: 135 MAIN ST, ANYTOWN, OHIO ZIP: 12345
TELEPHONE: (123) 555-8100

C	D	E	F	
SIZE: 140,163	BASE YEAR: 75-76	GRADES HOUSED: 9-12	REGULAR SESSION ENROLLMENT: 1357	SUMMER SESSION ENROLLMENT: 0

G			
REGULAR SESSION START DATE: 09-03-75	REGULAR SESSION NUMBER OF SCHOOL DAYS: 183	SUMMER SESSION START DATE:	SUMMER SESSION NUMBER OF SCHOOL DAYS: 55

H UNITS

	FLOOR PLAN IDENTIFICATION	FLOOR AREA	ROOF AREA	YEAR OPENED	YEAR MODERNIZED
UNIT I	⊗	99,273	81,365	1965	
UNIT II	⊗	16,940	9,695	1969	
UNIT III	⊗	21,500	21,500	1972	
UNIT IV	○				

SPECIAL USE SPACES

	UNIT NUMBER (1)	SIZE (2)	% COOLED (3)	REGULAR SESSION MONDAY FRIDAY DAYTIME DAYS/WEEK (4)	% USE (5)	EVENING DAYS/WEEK (6)	% USE (7)	SATURDAY SUNDAY DAYTIME DAYS/WEEK (8)	% USE (9)	EVENING DAYS/WEEK (10)	% USE (11)	TOTAL HRS/WK (12)	SUMMER SESSION MONDAY FRIDAY DAYTIME DAYS/WEEK (13)	% USE (14)	EVENING DAYS/WEEK (15)	% USE (16)	SATURDAY SUNDAY DAYTIME DAYS/WEEK (17)	% USE (18)	EVENING DAYS/WEEK (19)	% USE (20)	TOTAL HRS/WK (21)
I AUDITORIUM	III	21,500		5		2						38									
THEATER																					
GYMNASIUM	I	15,450		5		5		1				58	5								25
SHOWER/LOCKER	I	3,400		5		5		1				22	5								10
POOL ENCLOSURE																					
AUTO SHOP	I	7,216		5								30									
WOOD SHOP																					
METAL SHOP																					
KITCHEN	I	1,925		5								20									
CAFETERIA	I	3,395		5								30									
J PORTABLES																					
K GENERAL AREA OF UNITS — UNIT I		67,887	0	5	100	3	25					40									
UNIT II		14,490	0	5	100	3	25					40									
UNIT III		0																			
UNIT IV																					

COMMENTS

IDENTIFICATION	COMMENTS
GYMNASIUM	USED IN SUMMER BY COMMUNITY
	High School Sample Form

L — ENERGY USE

	PEAK DEMAND	$/KWH	TOTAL ELECTRICITY USE
ELECTRICITY	472	.0201	1,064,800
PRIMARY FUEL	FUEL TYPE 05	$/UNIT .33	TOTAL PRIMARY FUEL USE 84,000
SECONDARY FUEL	FUEL TYPE	$/UNIT	TOTAL SECONDARY FUEL USE

M — ENERGY USE PORTABLES

ELECTRICITY USED	
PRIMARY FUEL USED	
SECONDARY FUEL USED	

N — BOILERS CHILLERS

	DOMESTIC HOT WATER	BOILER B-1 ⊗	BOILER B-2 ⊗	BOILER B-3 ○	BOILER B-4 ○	CHILLER C-1	CHILLER C-2	CHILLER C-3	CHILLER C-4
TYPE		SB	SB	HB		CT ER ○	○	○	○
OUTPUT		MBTU 1,885	MBTU 1,885	MBTU 1,452	MBTU	TONS 75	TONS	TONS	TONS
FUEL		O	O	E		E			

O — KITCHEN

FUEL	ANNUAL FULL PREP MEALS	ANNUAL WARM UP MEALS
G	51,408	

P — POOL

FUEL	SURFACE AREA	START DATE	FINISH DATE

Q — INCINERATOR

FUEL	RATING - MBTUs	REG SES H/W	SUM SES H/W

R — KILNS FORGES

RATING	FUEL	REG SES H/W	SUM SES H/W
7.9	E	15	0
7.9	E	15	0

S — OUTDOOR LIGHTING

PARKING KW	ANNUAL KWH	FALL H/W	WTR H/W	SPR H/W	SUM H/W
4.6	5,020	28	28	28	

SECURITY KW	ANNUAL KWH	FALL H/W	WTR H/W	SPR H/W	SUM H/W
5	18,980	70	96	70	56

OTHER KW	ANNUAL KWH	FALL H/W	WTR H/W	SPR H/W	SUM H/W

TENNIS KW	ANNUAL KWH	FALL H/W	WTR H/W	SPR H/W	SUM H/W

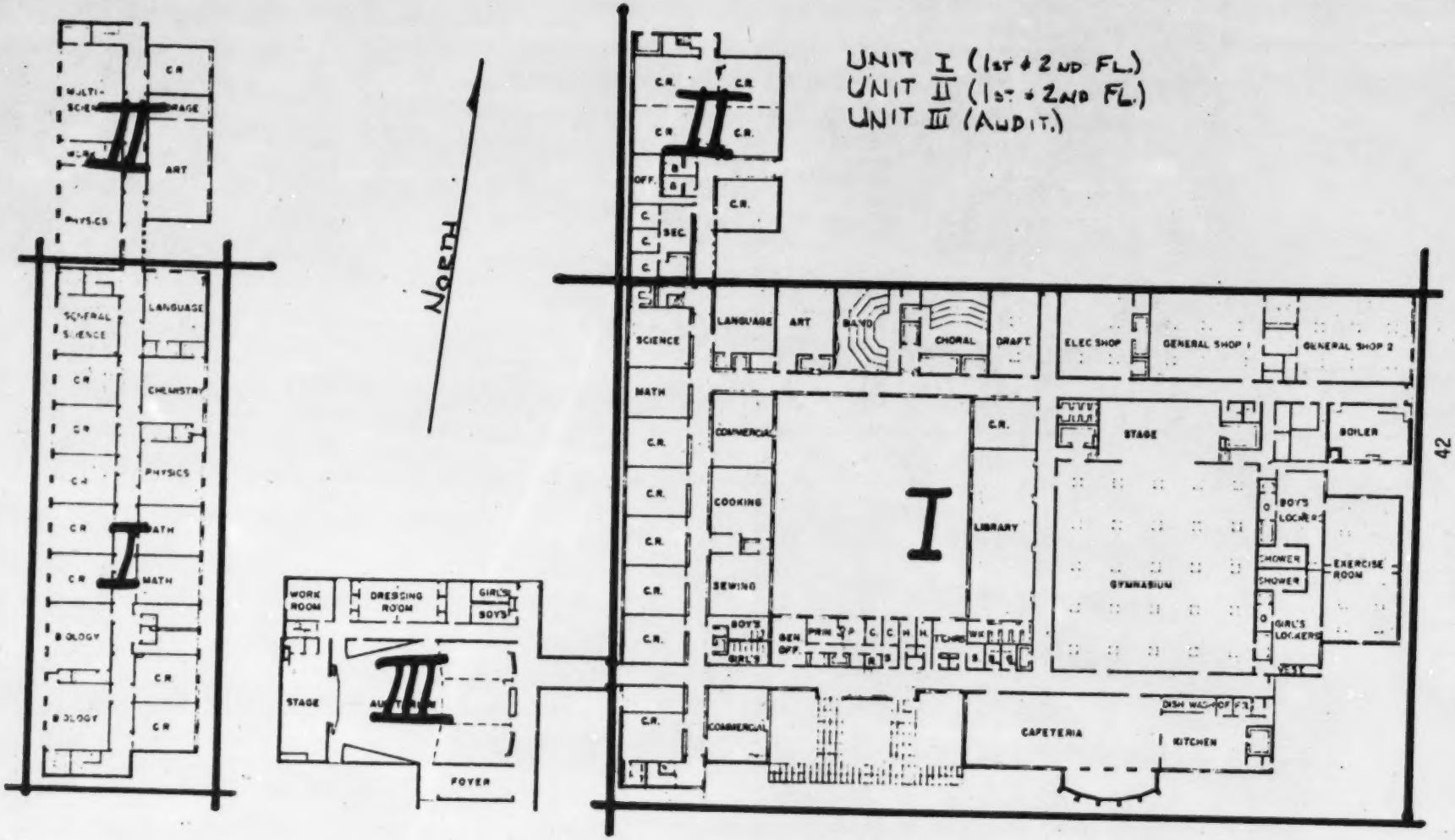
FOOTBALL KW	ANNUAL KWH	TOTAL HOURS/YEAR

HOCKEY KW	ANNUAL KWH	TOTAL HOURS/YEAR

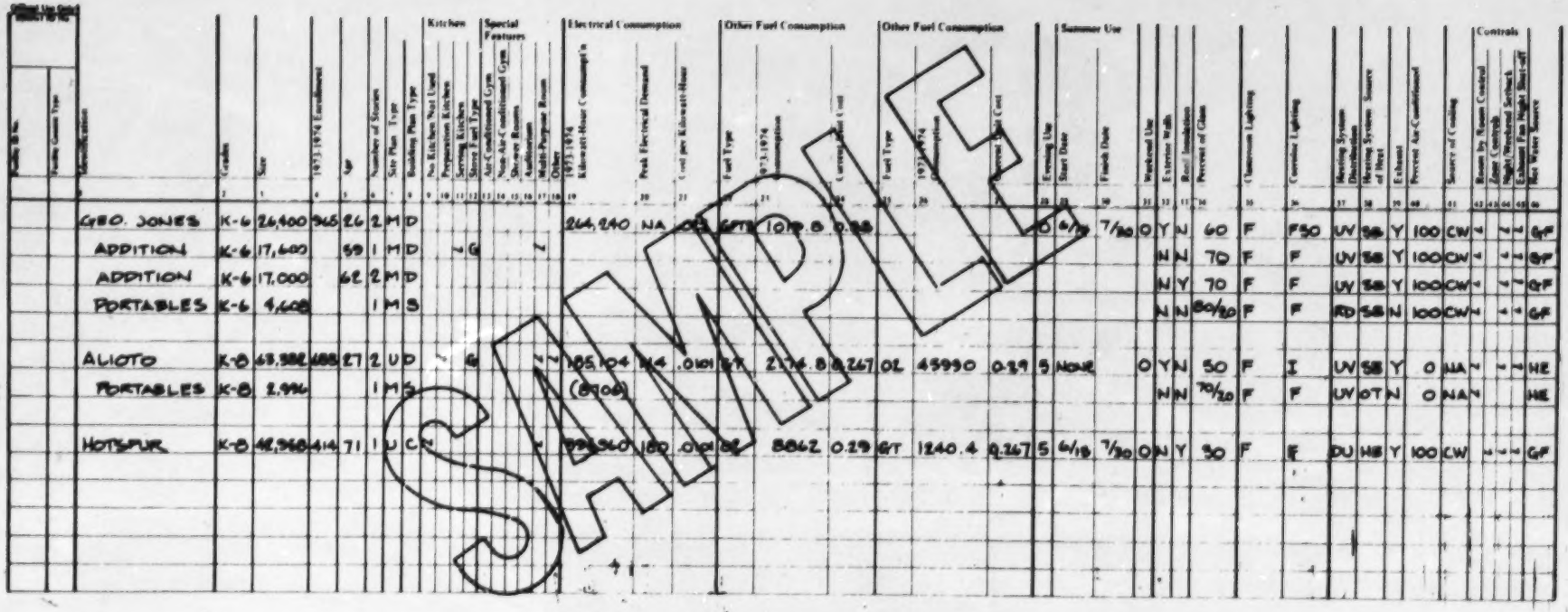
		DOMINANT SPACE USE 22	LIGHTS 23	GLASS: DOUBLE GLAZING AND GLASS BLOCK SQ FT 24	GLASS: SINGLE GLAZING SQ FT 25	GLASS: SKY-LIGHTS SQ FT 26	TYPE OF HEATING 27	WARM-UP CYCLE 28	HEAT SOURCE 29	VENTILATION 30	RETURN AIR 31	SOURCE OF MAKE-UP AIR 32	EXHAUST FANS H/W 33	SOURCE OF COOLING 34	REHEAT 35	NIGHT SET-BACK 36	SOURCE OF DOMESTIC HOT WATER 37
I	AUDITORIUM		I				DU		HB	VN	N			C-1	EL	FN	EL
	THEATER																
	GYMNASIUM		OT			400	DU		SB	EX				NA	NA	FN	HE
	SHOWER/ LOCKER		F		32		UV	↘	SB	EX		IA	22	NA	NA	SR	HE
	POOL ENCLOSURE																
	~~AUTO~~ SHOP		F		320	288	UH		SB	EX			30	NA	NA	NA	HE
	WOOD SHOP																
	METAL SHOP																
	KITCHEN		F		84		SR		SB	EX		IA	20	NA	NA	SR	HE
	CAFETERIA		F		336		UV	↘	SB	VN	N			NA	NA	SR	HE
J	PORTABLES																
T	UNIT I	CR	F		110		UV	↘	SB	VN	N			NA	NA	SR	HE
	UNIT II	CR	F		110		UV	↘	SB	VN	N			NA	NA	SR	HE
	UNIT III																
	UNIT IV																

SPECIAL USE SPACES

TYPICAL UNIT SPACE


UNIT I (1ST & 2ND FL.)
UNIT II (1ST & 2ND FL.)
UNIT III (AUDIT.)
NORTH
C.R.
ART
PHYSICS
LANGUAGE
CHEMISTRY
MATH
BIOLOGY
SCIENCE
COMMERCIAL
COOKING
SEWING
LIBRARY
BAND
CHORAL
DRAFT
ELEC SHOP
GENERAL SHOP 1
GENERAL SHOP 2
STAGE
BOILER
GYMNASIUM
BOY'S LOCKERS
GIRL'S LOCKERS
SHOWER
EXERCISE ROOM
CAFETERIA
KITCHEN
WORK ROOM
DRESSING ROOM
GIRLS
BOYS
FOYER
42

Elementary Form



Name	Grades	Size	10/31/74 Enrollment	#	Number of Stories	Site Plan Type	Building Plan Type	Kitchen: No Kitchen/Hot Lunch	Kitchen: Preparation Kitchen	Kitchen: Serving Kitchen	Kitchen: Stove Fuel Type	Special Features: Air-Conditioned Gym	Special Features: Non-Air-Conditioned Gym	Special Features: Shower Rooms	Special Features: Auditorium	Special Features: Multi-Purpose Room	Special Features: Other	Electrical Consumption: 10/31/74 Kilowatt-Hour Consumption	Electrical Consumption: Peak Electrical Demand	Electrical Consumption: Cost per Kilowatt-Hour	Other Fuel Consumption: Fuel Type	Other Fuel Consumption: 10/31/74 Consumption	Other Fuel Consumption: Current Unit Cost	Other Fuel Consumption: 10/31/74 Cost	Other Fuel Consumption: Current Unit Cost	Summer Use: Evening Use	Summer Use: Start Date	Summer Use: Finish Date	Weekend Use	Exterior Walls	Roof Insulation	Percent of Glass	Classroom Lighting	Corridor Lighting	Heating System Distribution	Heating System Source of Heat	Exhaust	Percent Air-Conditioned	Source of Cooling	Controls: Room by Room Control	Controls: Zone Controls	Controls: Night Thermostat Setback	Controls: Economy Cycle/Night Shut-off	Controls: Hot Water Source
GEO. JONES	K-6	24,400	345	26	2	M	D											244,240	NA	.03	GTR	1019.8	0.38			0	6/15	7/30	0	Y	N	60	F	F50	UV	SB	Y	100	CW	4			4	N	GF
ADDITION	K-6	17,600		59	1	M	D			G						X													N	N	70	F	F	UV	SB	Y	100	CW	4			4	N	GF
ADDITION	K-6	17,000		62	2	M	D																						N	Y	70	F	F	UV	SB	Y	100	CW	4			4	N	GF
PORTABLES	K-6	4,608			1	M	S																						N	N	80/20	F	F	RD	SB	N	100	CW	N			4	4	GF
ALIOTO	K-8	63,382	688	27	2	U	D			G						X		185,104 (8906)	114	.001	GT	2176.8	0.247	02	45990	0.39	S	NONE		O	Y	N	50	F	I	UV	SB	Y	0	NA	N			N	N	HE
PORTABLES	K-8	2,994			1	M	S																						N	N	70/20	F	F	UV	OT	N	0	NA	N					HE
HOTSPUR	K-8	48,968	414	71	1	U	C									X		995,360	180	.01	GT	8862	0.29	GT	1240.4	0.247	S	6/15	7/30	O	N	Y	30	F	F	DU	HS	Y	100	CW	N	N	N	GF	

SAMPLE

Name	Comments
ALIOTO	PLANT HAS WOOD SHOP, HOME EC. LAB. AUXILIARY WATER HEATER TYPE "EL"

Comments

instructions

The objective of the Public School Energy Conservation Survey (PSECS) is to provide you with the information you need to operate your facilities in the most efficient manner possible.

The next step in the program is to determine how each of your schools compares, with respect to energy consumption, with a similar school operating in your area on your schedule. The encouragement requested on this form is necessary in order to use computer models to make this comparison.

For questions concerning the survey write or call [illegible] Town Said Hall Road, Menlo Park, California 94025, (415) 854-7160.

Comments

The Comments Section of this form is provided to accommodate additional information which you wish to include or supplementary information which is requested on the form. Be sure to identify the facility even-coded with each comment.

Column 1 Identification

Enter all School Plants by grade level groupings, that is, enter all Junior High or Middle Schools etc.

If a School Plant consists of facilities built at different times, enter them on separate lines according to the following criteria:

(1) The Original/Main Building
(2) Significant Additions — Do NOT list any additions or separate facilities if they are the same basic type of construction as the Original/Main Building OR if they comprise less than 15% of the square footage in the entire School Plant.
(3) Portables — Consider all the Portables at the site as a single facility and enter them as a single line as PORTABLES.

Column 2 Grades

Enter the grades housed.

Column 3 Size

Enter the square footage of the facility. Do NOT include any unenclosed spaces.

Column 4 1973-1974 Enrollment

Enter the actual 1973-1974 enrollment for the entire School Plant at the time where the Original/Main Building is listed.

Column 5 Age

Enter the first year the facility was opened for use. Ignore Portables.

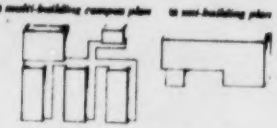
Column 6 Number of Stories

Enter the number of stories or separate levels. Ignore any story or separate level which accounts for less than 10% of the square footage of the facility.

Column 7 Site Plan Type

Enter "S" if the facility is or is part of a single building campus plan OR enter "M" if the facility is or is part of a multi-building plan.

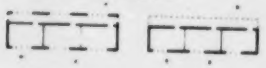
S multi-building campus plan — **M** mini-building plan



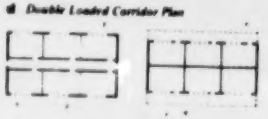
Column 8 Building Plan Type

Enter "S" if the facility is a Single Loaded Corridor Plan, enter "D" if the facility is a Double Loaded Corridor Plan and enter "C" if the facility is a Compact or Open Plan.

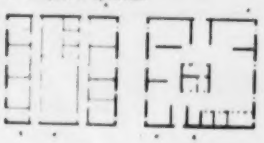
S *Single Loaded Corridor Plan*



D *Double Loaded Corridor Plan*



C *Compact or Open Plan*



Columns 9 thru 12 Kitchen

Describe the Kitchen of the facility as used during 1973-1974.

At columns 9 thru 11, enter a check mark in the column that best describes the 1973-1974 Kitchen use.

At column 12, enter G if the Kitchen stove fuel is Gas, OR enter E if it is Electricity.

Columns 13 thru 18 Special Features

Enter a check mark if, during 1973-1974, the Special Features noted in the columns were used. If the facility includes a Swimming Pool and the Community section of the form is provided, whether it is used by residents of the Swimming Pool was located during 1973-1974, and the type of fuel involved. Also, if the facility had some other Special Feature that might have been a large user of energy during 1973-1974, enter a check mark at column 18 (Other) and use the Comments section of the form to describe what the Special Feature was AND the type of fuel involved.

Columns 19 thru 21 Electrical Consumption

At column 19, enter the 1973-1974 Kilowatt Hour consumption.

At column 1 (Identification) each School Plant was broken down into three categories of facilities: (1) The Original/Main Building, (2) Significant Additions, and (3) Portables. Enter the total consumption for the entire School Plant at the line where the Original/Main Building is listed. If you have separate figures for any other category of facilities listed in column 1 (Identification), enter them in parentheses on the appropriate lines. Use the Comments section of the form to describe any other consumption figures that you have that do not lend themselves to this format.

At column 20, enter the 1973-1974 Peak Electrical Demand in Kilowatts. If this information is not available, enter "NA".

At column 21, enter the current cost per Kilowatt Hour.

Columns 22 thru 24 Other Fuel Consumption

At column 22, enter the descriptor that best identifies the type of fuel AND the type of users used during 1973-1974. If more than one of these types of fuel were used during 1973-1974, describe the second fuel consumption at columns 25 thru 27.

GT	Therms of Gas
GFT	Cubic Feet of Gas
GFT2	Hundreds of cubic feet of Gas
GFT3	Thousands of cubic feet of Gas
G2	Gallons of number two Oil
G4	Gallons of number four Oil
G6	Gallons of number six Oil
CHT	Tons of Hard Coal
CST	Tons of Soft Coal
OTHER	Other Fuel

At column 23, enter the 1973-1974 consumption of the fuel. The consumption must be expressed in the same units described at column 22. Enter the total consumption for the entire School Plant at the line where the Original/Main Building is listed. If you have separate figures for any other category of facilities listed in column 1 (Identification), enter them in parentheses on the appropriate lines. Use the Comments section of this form to describe any other consumption figures that you have that do not lend themselves to this format.

At column 24, enter the current cost per unit of the fuel. This cost must be expressed in the same units described at column 22.

Columns 25 thru 27 Other Fuel Consumption

Use these columns if more than one of the types of fuel enumerated at column 22 were used during 1973-1974.

Column 28 Evening Use

Enter the number which best describes how many evenings per week the facility was used during 1973-1974. Enter zero if the building was not used in the evenings. Do NOT include weekends.

Columns 29 and 30 Summer Use

If there was a summer program during 1973-1974, enter the Starting Date at column 29 and the Finish Date at column 30. If there was no summer program leave blank at the Start Date (column 29).

Column 31 Weekend Use

Enter zero if, during 1973-1974, the facility was typically not used during the weekend. Enter (1) if, during 1973-1974 the facility was typically used on Saturdays ONLY. Enter (2) if the facility was typically used on both Saturday AND Sunday.

Column 32 Exterior Walls

Enter "X" if the Exterior Walls are Masonry, Concrete or Insulated Metal Panel construction. If not, enter "N".

Column 33 Roof Insulation

Enter "Y" if there is insulation on the roof of the facility and enter "N" if not.

Column 34 Percent of Glass

Enter the Percentage of Glass on the exterior wall of a typical classroom.

To determine the percentage, select a typical classroom with exterior wall exposure (use classroom equivalents in open plans) and determine the percentage of the exterior wall that is glass. Do not use a corner classroom.

EXAMPLE

Percentage of Glass = Area of Windows / Area of Wall

Percentage of Glass in the example is 40%

In many plan configurations there will be one exterior wall in a typical classroom and therefore only one figure to enter as, for example 40%, 50%, 60%, etc. In many Single Loaded Corridor Plans, there are two exterior walls in a typical classroom. In such a plan, enter the percentage for each exterior wall as, for example 70%/50%, 40%/40%, etc.

Column 35 Classroom Lighting

Enter "F" if the typical Classroom Lighting is fluorescent OR enter "I" if the typical Classroom Lighting is incandescent.

Column 36 Corridor Lighting

Enter the lighting type found in the corridors. For Fluorescent enter "F" and for Incandescent enter "I". Where Corridor Lighting types are mixed OR where some corridors have fluorescent and others incandescent, give the percentage of the total number of fixtures that are fluorescent. For example, if there are one hundred light fixtures in the corridors and twenty of them are fluorescent, enter "F 20".

Column 37 Heating System Distribution

Enter the two-letter descriptor that best understates the way the facility is heated. If the facility has more than one type of system AND the secondary system considers more than 10% of the facility, describe it in the Comments section of the form.

RD	Radiators, Strip Convectors or Radiant Panels
UV	Unit Ventilators or Fan Coil Units
ME	Mechanical
VV	Variable Volume
DU	Single Duct or Dual Duct
AE	All Electric

Column 38 Heating System Source of Heat

Enter the two-letter descriptor that best identifies how the heat in the building is generated.

SB	Steam Boiler
HB	Hot Water Boiler
OT	Other

Column 39 Exhaust

Enter "Y" if the typical teaching space has some form of mechanical exhaust and enter "N" if it does not.

Column 40 Percent Air-Conditioned

Enter the percentage of the facility that is fully air conditioned (heated and cooled). Accuracy to the nearest 10% is sufficient. Enter 0% if less than 10% or none of the building is air-conditioned.

Column 41 Source of Cooling

Enter the descriptor that best identifies the cooling source for the air-conditioning of the facility.

DX	Direct Expansion as in self-contained unit ventilators or packaged rooftop units.
CW	Chilled Water as in a central refrigeration unit with pipes to cooling coils
AC	Air-cooled, as in an air-cooled condenser (Swamp Cooler)
NA	Not Applicable as in there is no air conditioning

Columns 42 thru 45 Controls

Mark the column(s) that best describe the type(s) of controls on the mechanical system.

Column 46 Hot Water Source

Enter the two-letter descriptor that best identifies how domestic hot water is generated. If there is more than one hot water heater, note the auxiliary source in the Comments section of the form.

HE	Heat Exchanger from the Boiler
OF	Separate Oil-Fired Water Heater
GF	Separate Gas-Fired Water Heater
EL	Electric Water Heater
OT	Other

PSECS SUMMARY REPORT ON ENERGY CONSERVATION FOR MINNEAPOLIS MN 12/14/75

DISTRICT DATA 1973/1974 787. CLG D-D 7962. HTG D-D ENERGY FIGURES ARE IN MBTU/SQ FT/YR

						ELECTRIC ENERGY 1973/1974				FUEL ENERGY 1973/1974				
						USAGE		EST. SAVINGS		USAGE		EST. SAVINGS		TOTAL
	PLANT		GT	AREA	PC	ACTUAL	GUIDEL	ENERGY	COST	ACTUAL	GUIDEL	ENERGY	COST	SAVINGS
1	CLEVELAND	K-6	10	34811.	28.	6.71	9.03	0.00	$ 0.	153.61	108.77	44.84	$ 1768.	$ 1768.
2	HOLLAND	K-6	32	56000.	7.	14.76	24.04	0.00	$ 0.	60.88	55.64	5.24	$ 325.	$ 325.
3	HOWE	K-6	10	34811.	17.	6.69	8.77	0.00	$ 0.	131.40	107.61	23.79	$ 984.	$ 984.
4	KENNY	K-6	20	48120.	18.	12.68	10.56	2.13	$ 1171.	152.00	124.79	27.20	$ 2941.	$ 4111.
5	LORING	K-6	10	34811.	15.	6.18	9.57	0.00	$ 0.	130.96	110.91	20.05	$ 791.	$ 791.
6	MINNEHAHA	K-6	10	34811.	16.	7.27	9.89	0.00	$ 0.	133.94	111.68	22.26	$ 905.	$ 905.
7	PAGE	K-6	20	31258.	0.	8.02	10.29	0.00	$ 0.	111.02	119.72	0.00	$ 0.	$ 0.
8	PUTNAM	K-6	32	44264.	49.	17.57	26.60	0.00	$ 0.	114.84	50.16	64.67	$ 3355.	$ 3355.
9	STANDISH	K-6	10	58408.	0.	6.18	11.11	0.00	$ 0.	87.77	134.88	0.00	$ 0.	$ 0.
10	CLARA BARTON	K-6	10	49086.	0.	6.61	11.64	0.00	$ 0.	113.10	146.92	0.00	$ 0.	$ 0.
11	TUTTLE	K-6	10	53380.	0.	6.67	11.71	0.00	$ 0.	71.76	147.90	0.00	$ 0.	$ 0.
	TOTALS	PLANTS (11)				PLANTS (11)			$ 1171.	PLANTS (11)			$ 11069.	$ 12239.

12/14/75

PSECS ENERGY CONSERVATION REPORT CN-

10 CLARA BARTON K-6

8 MINNEAPOLIS MN

THIS PLANT IS CLASSIFIED AS AN E1 PREWAR LOW ENERGY PLANT

AREA 49066. SQUARE FEET 1973/1974 ENROLLMENT 425.

DURING BASE YEAR THIS SCHOOL WAS USED FOR THE SCHOOL DAY PLUS

2.NIGHTS PER WEEK, FOR 8. WKS/SUMMER

**********ENERGY SAVINGS**********

COMPARISON OF ENERGY USE AT THIS PLANT WITH THAT OF THE PSECS GUIDELINE MODEL INDICATES THAT THIS PLANT WAS OPERATING EFFICIENTLY DURING THE BASE PERIOD. ADDITIONAL SAVINGS MAY RESULT FROM FURTHER CONSERVATION EFFORTS.

		ACTUAL USE 1973/1974	GUIDELINE 1973/1974	ESTIMATED SAVINGS
NATURAL GAS	MCF	4987.	6462.	0.
#2 FUEL OIL	GALLONS	2250.	2896.	0.
ELECTRICITY	KWH	95040.	167336.	0.

THIS REPRESENTS AN ESTIMATED ANNUAL COST SAVING OF

		ESTIMATED SAVINGS	PRICE PER UNIT	ESTIMATED SAVINGS
NATURAL GAS	MCF	0.	$ 1.157	$ 0.
#2 FUEL OIL	GALLONS	0.	0.339	0.
ELECTRICITY	KWH	0.	$ 0.029	$ 0.
TOTAL ESTIMATED SAVINGS				$ 0.

****

INTRO 10 CENAC RACIA FLLCR

PSECS CAPITAL MODIFICATIONS SURVEY FOR MINNEAPOLIS MN 8

10 CLARA BARTON K-6

MODIFICATION	ESTIMATED CAPITAL COST	ESTIMATED ANNUAL SAVINGS ELECTRICITY COST	ELECTRICITY KWH	HEATING FUEL COST	HEATING FUEL UNITS	YEARS TO RECOVER LINEAR ($C/$S)	YEARS TO RECOVER INTEREST (0.070)
ROOF INSULATION (TYPE=2)							
INCREASE BY R=10	$ 15000.	$ 8.	275.	$ 995.	860.	15.0	28.2
INCREASE BY R=20	$ 17000.	$ 9.	309.	$ 1119.	967.	15.1	28.5
INCREASE BY R=30	$ 19000.	$ 9.	323.	$ 1168.	1009.	16.1	30.5
INSULATING GLASS IN WINDOWS							
NORTH FACING	$ 6317.	$ 0.	9.	$ 102.	88.	62.0	****
EAST/WEST FACING	$ 27373.	$ 0.	79.	$ 429.	370.	63.8	****
SOUTH FACING	$ 25267.	$ 0.	51.	$ 363.	314.	69.6	****
REDUCE GLASS AREA 50 PER CENT							
NORTH FACING	$ 370.	$ 0.	17.	$ 76.	66.	4.8	9.1
EAST/WEST FACING	$ 1602.	$ 5.	185.	$ 282.	244.	5.6	10.5
SOUTH FACING	$ 1478.	$ 5.	170.	$ 163.	141.	8.8	16.6
ABOVE PLUS DOUBLE GLASS							
NORTH FACING	$ 6552.	$ 0.	11.	$ 144.	125.	45.3	85.5
EAST/WEST FACING	$ 28392.	$ 7.	234.	$ 570.	493.	49.2	92.9
SOUTH FACING	$ 26208.	$ 6.	201.	$ 413.	357.	62.6	****
SHADE EXISTING WINDOWS							
REDUCE INFILTRATION	$ 7363.	$ 0.	0.	$ 496.	429.	14.8	28.0
ADD NIGHT SETBACK	$ 500.	$ 0.	0.	$ 1081.	935.	0.5	0.9

ASSUMED RATE OF FUEL COST INFLATION 0.0 PER CENT PER YEAR

FUEL TYPE AND UNITS ARE NATURAL GAS MCF AT $1.157
ELECTRICITY KWH AT $0.029

Public Schools Energy Conservation Service

Plan 1 Operation Audits of x number of elementary and secondary schools. Districts to provide data to EFL, which will run the schools and provide computer printouts of the results to both the state and the district.

EFL Cost - $20.00 for each elementary school
$35.00 for each secondary school
Additional Costs: State may wish to provide assistance to some districts in compiling their data.

Plan 1A Capital Audits The state may wish to select a number of schools from those which have been run under Plan 1 for capital audit. EFL's computer programs will select appropriate modifications for each school, and provide computer printouts to the district and the state.

EFL Cost - Estimated at $10.00 per elementary school
$15.00 for each secondary school
Additional Cost: State may wish to develop capital assistance program based on cost/benefit analysis of this type.

Plan 2 Operations Audits/Capital Audits - State or Local level. EFL to provide all software and training required to set up the PSECS for operation by the designated governmental unit.

EFL Cost - Variable, depending on capabilities of the unit, distance from EFL. Preliminary estimate, $7,000 - $10,000.
Additional Cost: Unit would need to supply hardware and staff for collecting and processing data.

Plan 2A Extension of Plan 2, to include a monthly reporting system and monthly energy use guidelines.

EFL Cost - When combined with Plan 2, the additional cost should not be more than $1,000.

Many variations of the four plans described are possible. EFL personnel will be glad to answer any questions concerning any aspect of our operations.

Enclosures: PSECS Brochure
PS1
Sample Printout

APPENDIX III

MINI AUDIT

of

CLARA BARTON ELEMENTARY SCHOOL (TYPE 1)

4237 Colfax Avenue South

Minneapolis, Minnesota 55409

February 21, 1975

by

Minnesota Team

W. Herbert Doty - Minnesota Gas Company
Dale M. Pederson - Northern States Power Company
Samuel J. Stewart - Minnesota Energy Agency

Observers

Sid Inman - Minneapolis Public Schools
Jere Phillips - Minneapolis Public Schools
Dave Urbanski - Minneapolis Public Schools

SCHOOL MINI AUDIT FORM

Name of School Clara Barton Address 4237 Colfax Avenue South

Name of School District MPS State Minnesota

Person to Contact Sid Inman Telephone 348-6237

Type of School 1

Year Building Constructed 1915 (library 1972)

Number of Students 423 Number of Floors 2 + basement

Gross Area 50,986 Sq. Ft.

Type of Construction Reinforced concrete

Type of Windows and Approximate % of Wall Single pane, double hung windows, no caulking or weatherstripping

Storm Windows No

Roof Insulation Minimum 1" Perlite Insulation

HEATING SYSTEM

1. Type and Number of Boilers/Furnaces Kewanee Steam Boiler, Ace Burner, Gas/#2 oil
2. Size of Boilers 1,018
3. Type of Heating Terminal System Steam radiators/steam coils
4. Type of Thermostatic Control Room thermostats
5. Steam Pressure or Water Temperature 5
6. Last Flue Gas Analysis ?
7. Damper Control Manually adjusted
8. Temperature of Classrooms Days ? and Nights ?
9. Temperature of Hallways ?
10. Heating System Description:

The school is heated by a steam boiler that is fueled by interruptible natural gas and No. 2 fuel oil. The boiler system was converted from hand-fired coal to combination gas oil about 6 years ago. Heat is distributed via steam radiation and steam coil ventilation. The boiler is normally turned off during the winter at 6 p.m. on weekdays, unless they have a night function which occurs about 2 nights per week. On cold nights, the boiler is started manually at 5 a.m. instead of 6 a.m. and the temperature in certain spaces drops to approximately 55°F.

The boiler is a Kewanee steam boiler with an Ace burner that maintains about 5 pounds steam pressure. The boiler was cycling on and off when were observing and the stack temperature was about 370° on low fire and 480°F on high fire.

HEATING SYSTEM COMMENTS

(1) Consider automating the boiler to start automatically when space temperature drops below a preset night temperature.

(2) Consider having a competent combustion engineer take a flue gas analysis. The stack temperature on high fire indicates the burner fuel air ratio requires adjustment.

(3) The boiler damper control is not functioning properly. It is sequencing but not controlling. The draft gauge indicates 0.18" water column under low fire which is much too high. Consider readjustment of this damper control to maintain proper draft under both high and low fire.

(4) Consider reducing the space temperature in all classrooms within the building to 68°F. On the day we conducted the audit, most of the classrooms were at 70°F or higher.

(5) Consider readjusting all of the room thermostats so that they can maintain a control point temperature setting of 68°F.

(6) Consider adding some type of a key switch to each of the hallway radiation valves so that the students cannot change the setting of the steam valves.

DOMESTIC HOT WATER SYSTEM

1. Type of System Small hot water heater

2. Water Temperature 140°

3. Special Use Facilities

Pool no Kitchen no

No. of Shower Heads -- No. of Meals/Day --

Comments

(1) Consider reducing the restroom hot water temperature from the present setting to approximately 100-110°F.

VENTILATION SYSTEM

The steam coil ventilation system has the capability of heating outside air up to 70°F. The ventilation system has manually adjustable outside air dampers and almost no return air. The ventilation system is normally shut down at 6 p.m. weekdays, and operated approximately 4-6 hours on Saturdays and Sundays to keep the building from freezing. According to the operation engineer, the temperature in certain rooms has dropped to 38-40°F before the ventilation system has been turned on.

Comments

(1) Consider operating the ventilation system only when the school is occupied. If the steam radiators are located properly, they should be able to maintain space temperatures above freezing.

(2) Consider adjusting the manual fresh air dampers to reduce the quantity of outside air heated by the ventilation system. Also consider modifying the ventilation system to permit more return air to be recirculated. If this is done the fresh air/return air should be controlled with motorized dampers.

(3) Consider operating the gym 100% outside air ventilation unit on a reduced operating schedule that coincides with occupancy of the gym. Also consider the possibility of changing the outside air damper setting to reduce the amount of outside air brought into the gym when the fan unit is operating. The gym fan unit should not be turned on until the first class occupies the gym and should be turned off immediately after the class leaves the gym in the afternoon.

LIGHTING SYSTEM

Typical Classroom Lighting

Type of Fixtures Partial incandescent and fluorescent

Watts/Sq. Ft. Minimum

Typical Hallway Lighting

Type of Fixtures Partial incandescent and fluorescent

Watts/Sq. Ft. Minimum

Comments

(1) Consider turning off boiler room lights when unoccupied.

(2) Consider turning off the vestibule entrance lights during daylight hours.

(3) Consider acquiring energy conservation reminders such as posters and individual decals that can be located next to the light switch to alert both students and teachers that energy conservation is their responsibility.

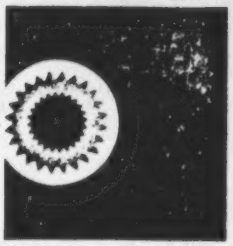
(4) Consider the addition of separate light switching in certain spaces throughout the school.

(5) Consider leaving the gym lights off except when occupied.

BUILDING CONSTRUCTION

(1) Consider caulking and weatherstripping all of the windows i the building. If this is done the school can be maintained at a positive pressure with the addition of very little outside air.

APPENDIX IV



MODEL MAXI-AUDIT CONTRACT FOR CONSULTANT SERVICES

DUTIES OF CONSULTANT

Consultant shall make a comprehensive energy study of _____ school located at _____

This study will include a detailed list of recommended energy conservation measures separated into the following grouping of energy using functions.

Space Heating — Boiler Room
Domestic Water Heating
Ventilation (temperature control)
Air Conditioning
Lighting
Building Structure
Miscellaneous

All of the energy used in the school can be assigned to the several functions described above. Because these functions are interrelated in several ways, there may be some overlapping of recommended conservation suggestions. Conservation measures for each function should be categorized in two areas:

(1) Measures that can be implemented quickly at little or no cost, usually less than $200.00 in the Operations and Maintenance (O&M) area:
(2) Measures that require substantial retrofitting and will entail some—though not extensive—capital investment.

Consultant shall estimate investment required for item 2 measures.

Maxi-Audit (Description)

In the absence of records from extensive submetering systems, it is necessary to conduct an inventory of energy-using apparatus to calculate the design loads under existing operating conditions to project the normal monthly use of energy in a respresentative weather year, and to divide the recorded monthly purchases of electricity, gas, oil, coal, steam, etc. among the functional uses in accord with prudent judgment based on the inventory and calculations.

A careful survey of the building facilities must be undertaken to identify the energy-using apparatus, to *measure or estimate* the rate of energy use at each device and to determine the circumstances that control the frequency and duration of operation and the part-load response.

It is helpful to start with a set of "as built" construction drawings, accurate test and balance data, definitive temperature control system diagrams and a descriptive sequence of operations. In any event, it is necessary to determine: the physical dimensions of the building; construction materials used; compass orientation; shading effect of adjacent buildings or permanent plantings; applicable ventilation requirements; complete data on illuminating systems, people occupancy, appliances and equipment used in the building. From these data the Design Heating, Ventilating and Cooling Loads can be calculated for the extreme outdoor weather conditions, winter and summer, and the desired interior temperatures and humidity. Detailed instructions on a standard method of performing this calculation are included in ASHRAE Handbook of Fundamentals, 1973.

The results of design load calculations can be used to estimate the annual heating and cooling loads *by manual or computerized procedures* that simulate operational conditions, the influence of hours of occupancy and a model year weather occurrence including available sunshine and the annual 8760 hourly occurrences of dry bulb and wet bulb conditions.

The inventory of energy-using apparatus should include the equipment used for functions other than adding and removing heat. Each such item or grouping of items should be assigned a maximum rate of energy consumption and a program of start, stop and part-load performance for each month. These data are then combined to produce the monthly and annual BTU and KWH of energy used for operation of these Air Handling, Fluid Handling, Hot Water Heating, Appliance, Process, Transportation, Interior and Exterior Illuminating Functions.

The total monthly BTU of heat energy required for all heating functions should then be divided by appropriate monthly fuel conversion efficiency factors to determine net heating fuel energy required per month in a normal year.

The total monthly heat gains and hours of refrigeration plant operation for each month must be used to produce the monthly KWH of electricity (and BTU of heat, where applicable) to absorb the building heat gains and transfer them to the environment.

After the estimated energy use has been calculated for applicable energy use functions, the monthly records of electricity, gas, oil, coal, steam, etc., for two or more years should be analyzed. Heating fuel should be converted to BTU of heat content purchased per month. The demand and energy consumption records on the electric bills may be used directly. These records should be adjusted to reflect any known deviations from the "normal" year usage and weather data used in the calculated energy estimate and an adjusted month-by-month tabulation of purchased fuel BTU and electric KW and KWH should be developed.

The adjusted purchased energy tabulation should then be compared with the calculated energy budget estimate to identify substantive differences. Where deviations are significant, the budget estimate assumptions should be reviewed. If the budgeted values are deemed realistic, then the source of excessive energy consump-

tion should be identified and an evaluation should be made of the cost/benefit relationship to improve the condition. Analysis of the quantity of energy used for each function will reveal the areas in which remedial effort may produce significant results. Adjustment of performance levels of the various building services or other changes that reduce design loads and modify operating characteristics may be analyzed for impact on costs and energy consumption. Simulation of the effects of proposed modifications can be individually considered to optimize effort and expense.

Suggested Maxi-Audit Procedure

Actual audits may deviate from this procedure when the following suggested criteria are not appropriate.

A. Calculate design heating and cooling loads for the building as constructed and used.
   1) Compare construction drawings to existing conditions to identify any deviations, such as: Window shading devices, infiltration characteristics of windows and doors, quality of thermal insulation, illumination devices installed and used, appliances and process equipment in use, substantial reassignment of space functions, etc.
   2) Establish operating techniques that are currently employed: Temperature and humidity conditions maintained, ventilation rate used, operating capacity and power requirements of fans, pumps, compressors, etc.
   3) Based on drawings and observations, calculate maximum heating load at winter design conditions and summarize sub-totals:
      a) BTU per hour conduction loss with no solar or internal heat gains.
      b) Outdoor air infiltrated, CFM when building ventilation equipment is off.
      c) Outdoor air introduced and exhausted, CFM when ventilation equipment is ON.
   4) Based on drawings and observations, calculate maximum cooling load at summer design conditions and summarize sub-totals:
      a) BTU per hour conduction gain at simultaneous peak time.
      b) BTU per hour solar heat gain at peak condition for each of cardinal compass points and for horizontal surfaces.
      c) Outdoor air introduced and exhausted, CFM when ventilation equipment is on in the cooling mode.
      d) BTU per hour of heat gained in the building from illumination devices.
      e) BTU per hour of heat gained in the building from appliances and processes.
      f) BTU per hour of heat gained from building occupants.
      g) BTU per hour of heat gained from temperature control system and HVAC components.
   5) Based on drawings and observations, calculate normal electrical energy used, KW per hour, occupied and unoccupied modes, *by heating and air conditioning distribution apparatus.*
   6) Based on drawings and observations, calculate normal electrical energy used, KW, or heat energy used, BTU per hour, occupied and unoccupied modes, by processes and appliances that are not included in "4" above. DO NOT include energy requirements of fuel conversion process or refrigeration for air conditioning in this summary.
      a) Building transportation, elevators, escalators, conveyors, etc.
      b) Domestic water pumps, sewage and sump pumps, drinking water coolers.
      c) Food refrigeration and cooking.
      d) Domestic water heating and laundry operations.
      e) Process air compressors.
      f) Boiler accessories, feed water systems, fuel pumps.
      g) Office and production machinery.
      h) Miscellaneous.

B. Calculate monthly energy load and annual totals for the *building heating, ventilation and cooling* requirements during normal use and weather. (Energy Output)
   1) Determine occupancy levels and durations for major building areas.
   2) Establish performance requirements of automatic temperature control system and components and identify impact of control sequence on refrigeration and heating loads.
   3) Determine programs of start-stop of apparatus, heat-cool changeover criteria, winter unoccupied mode set back temperature, utilization of outdoor air for non-refrigerated cooling, exhaust air equipment operating schedule.
   4) Establish a model weather year, including local normal outdoor temperature and humidity experience for each month and characteristic local interference with available sunlight because of cloud cover or other atmospheric conditions. Weather experience should be indexed to the usual occupancy conditions of the building so that weather incidents that occur when the building is unoccupied are separated from the weather that is coincident with building occupancy.
   5) Based on the data assembled, calculate normal monthly totals of energy required to serve the heating, cooling and ventilation loads established and tabulate in sufficient detail to allow analysis. The calculation must include a simultaneous determination of heat losses and gains for each weather incidence and with appropriate considerations of applicability of the gains to the losses. In addition, the calculations must account for the automatic and manual control of the heating and cooling apparatus so as to reflect the response of the energy using equipment to changing requirements of weather and occupancy.

C. Calculate monthly consumption of energy and annual totals required by the *building systems.* (Energy Input)
   1) Tabulate fuel input (or electric energy) to serve heating, domestic hot water and process loads, including suitable provisions for conversion efficiency at varying loads.

2) Tabulate electric energy input for refrigeration system components required to serve the air conditioning loads.
3) Tabulate fuel input to serve heat actuated refrigeration equipment required to serve the air conditioning load.
4) Tabulate electric energy input separately for interior illumination, air handling equipment, fluid handling equipment, boiler and heating accessories, and other electrical loads.

D. Compare and adjust calculated energy input totals with records of fuel and electricity purchase records for a two-year span.
1) Adjust records of monthly fuel and utility bills to reflect (a) Calendar months in lieu of billing periods, and (b) Aberrations in experience because of deviations from normal occupancy and weather.
2) Compare calculated energy input with adjusted records of fuel and utility purchases. Where calculated energy is greater than adjusted purchases, review the calculation input information and adjust the calculations to reflect actual usage. This revised tabulation is the Energy Budget. Where purchased energy exceeds the Budget, there is opportunity for increased efficiency of utilization.

E. *Recommend Energy Conservation Measures* (Separate into standard groupings)
1) Analyze the Maximum Heating and Cooling Loads to determine opportunities for load reduction by modification of the building envelope thermal effectiveness and for changes in ventilation rate and boiler modifications. The probable results of such changes can be measured or estimated by recalculating the annual energy use and determining the effect on energy purchases.
2) Analyze the energy used by air handling and fluid handling equipment. If substantial changes are made in Heating and Cooling Loads, it may be possible to make beneficial revisions to the apparatus and use of these sub-system components to further reduce energy consumption.
3) Analyze the building automation systems and determine the effects of changes to start-stop programming, night setback, temperature control sequences and set points. Changes in occupancy schedules should be considered in assessing possible reductions of hours of equipment operation.
4) Review budgeted allowances for Processes and Appliances and make detailed analysis where the quantities justify the effort.
5) Review budget allowances for illumination energy and analyze apparatus, performance levels and operational techniques to reduce energy consumption. If substantial changes are made in reducing illumination energy use, the Heating and Cooling Loads will be affected and there may be beneficial revisions in other energy uses.
6) Analyze budget allowances for energy conversion apparatus, i.e. refrigeration system, fuel conversion equipment, etc., and calculate annual efficiencies. Considering probable changes in building loads, operation schedules, temperature control system, etc., estimate possible impacts on energy conversion efficiencies.
7) Recalculate the annual energy uses for the project as it would be modified by energy conservation measures selected as most probable. This evaluation will provide a reasonable basis for predicting effects of proposed changes on energy purchases.
8) Identify the expected reduction in energy use for each proposed change in the program so that the performance can be measured and the responsibility for continued surveillance can be allocated.
9) Develop suitable monitoring procedures to record the performance of modified equipment or procedures. Recommend instrumentation such as:
a) Elapsed time meters to record hours of operation of prime movers.
b) Electric watthour meters to record usage of electric energy for specific operations or departments.
c) Fuel meters to record consumption of fuel for specific operational purposes.
d) BTU meters, steam flow meters or condensate meters to identify heat input or output of processes or building environmental apparatus.
e) Recording thermometers to verify performance of critical automatic temperature controls.
f) Recording ammeters to monitor relative load changes in electric prime movers and power distribution feeders.
10) Develop reporting procedures and summaries to monitor the operating and maintenance personnel execution of energy conservation program elements. Daily, weekly and monthly logs of equipment use, meter readings and performance evaluations should be summarized and reported to operating personnel. Continued reference to performance goals and actual achievement is necessary to sustain interest and reward successful effort and skill at the level at which operating decisions are actually made.
11) Prepare comparative statements of energy use semi-annually to show the actual purchases of electricity and fuel compared to the Energy Budget and the Adjusted Record of Energy purchased in the past. Graphic presentations may provide a continuing synopsis of the effects of energy conservation programs.